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HARVARD UNIVERSITY
JUL 13 1945
GRADUATE SCHOOL
OF PUBLIC ADMINISTRATION

EVIDENCE

BEFORE THE

GOVERNOR AND COUNCIL

IN RELATION TO THE

Troy and Greenfield Railroad:

WITH THE

DECISION OF THE GOVERNOR.

Phonographically Reported
BY J. M. W. YERRINTON.

PUBLISHED BY THE
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INDEX.

Page.
Order of Council, ... 4
Preliminary Statement by His Excellency, the Governor, . . . 5
Testimony of Samuel Nott, Superintendent of the Hartford, Providence and Fishkill Railroad, Hartford, ... 9, 47, 60
Testimony of Isaac Hinckley, Lowell, ... 25
Testimony of T. Willis Pratt, Railroad Engineer, Plainfield, Conn., . 25
Testimony of Capt. William H. Swift, Civil Engineer, . . . 30
Testimony of Robert Harris, Civil Engineer, Portsmouth, N. H., . 33
Testimony of Charles S. Storrow, Civil Engineer, Boston, . . . 34
Testimony of James Hayward, Civil Engineer, Boston, . . . 36
Testimony of Charles Russell, Road-master of Western Railroad, Springfield, ... 39
Testimony of Martin B. Inches, Civil Engineer, Boston, . . . 41, 61
Testimony of Gordon H. Nott, Civil Engineer, Boston, . . . 42, 61
Testimony of Samuel Ashburner, Civil Engineer, Boston, . . . 43
Testimony of Thomas S. Williams, Boston, ... 46
Testimony of Alexander Holmes, President Old Colony and Fall River Railroad, ... 48
Testimony of Gen. George Stark, Superintendent of the Lowell and Nashua Railroad, Nashua, N. H., ... 49
Testimony of William B. Brinsmade, Superintendent Conn. River Railroad, ... 51
Testimony of Lewis Broad, Railroad Contractor, Boston, . . . 55
Testimony of C. L. Stevenson, Civil Engineer, Charlestown, Mass., . 56, 61
Estimate of work remaining to be done upon the Troy and Greenfield Railroad, east of Hoosac Tunnel, at the time of the suspension of operations, July, 1861, ... 60
Decision of His Excellency, the Governor, ... 62
Letter of His Excellency, the Governor, to the Attorney-General, on the law questions involved, ... 63
Reply of the Attorney-General, and Opinion, ... 64

APPENDIX.

Report of William S. Whitwell, State Engineer, on the condition of the Troy and Greenfield Railroad, ... 83
Letter of the State Engineer to the Attorney-General, . . . 87
Letter of Herman Haupt to the Attorney-General, ... 89

Commonwealth of Massachusetts.

COUNCIL CHAMBER, September 25, 1861.

Ordered, That the evidence taken in the hearing in relation to the Troy and Greenfield Railroad, together with the opinion of His Excellency the Governor, as delivered to the Council, be printed under the supervision of the Secretary of the Commonwealth.

Adopted in Council:

OLIVER WARNER, *Secretary of the Commonwealth.*

EVIDENCE BEFORE GOVERNOR AND COUNCIL.

FIRST DAY.

TUESDAY, September 24.

The hearing in relation to the Troy and Greenfield Railroad, originally commenced before a Committee of the Council, August 13th, and terminating the day following, was resumed before the full Board, on Tuesday, September 24, 1861, His Excellency, the Governor, in the Chair.

The GOVERNOR stated the purpose of the hearing, as follows:—

There are two or three questions of the practical application of engineering science to the construction of railroads, which have arisen in reference to that part of the Troy and Greenfield Railroad which lies between its eastern terminus in Greenfield, and the Hoosac Mountain; and the gentlemen who have been requested to attend to-day, by summons, in the character of professional experts, have been so requested in the hope that their testimony will illustrate some of these questions.

I do not propose, myself, to put to the gentlemen many interrogatories, and desire that the examination shall be confined strictly to the practical questions which actually arise, for the purpose of ascertaining what is our duty in the present aspect of the affair.

The questions, as I understand them, are, in substance, three; and they arise out of the report recently made by Mr. Whitwell, the State Engineer, in reference to the present condition of the road.* One touches the substantial character of the bridge in Greenfield, over the Green River; another involves the question whether, if the trestle-work over ravines is left unfilled, the construction of the road, so far as it relates to building over ravines, is to be considered a substantial construction; another is, whether slopes left at an angle of forty-five degrees, or what is commonly called of one to one, are or are not too steep. I believe the questions relating to the bridge, the trestle-work, and the slopes, are the only practical questions which are now raised.

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* See Appendix, A.

I make this statement in the hearing of the gentlemen summoned as witnesses, in order that they may be prepared, in their own minds, to reflect on these questions, and not left at random to consider all possible questions relating to engineering science. And in the first place, I suppose it is desirable that some description be given, as nearly as possible, in order that gentlemen who have not seen the road may be enabled to have a better basis of opinion. I endeavored to obtain the plans and profiles for exhibition to-day, and telegraphed to Greenfield yesterday for that purpose; but they are in the custody of Mr. Haupt, who happens to be detained in Philadelphia, and no one else could procure them. If any gentleman of the Council remembers that any other question of practical science is open, I should like to have him state it now, in order to avoid any misconception.

The Hon. Mr. Greene suggests that one question which might properly be put would be, whether it is usual to perfect the slopes before the road is put into operation, or to leave the slopes to be perfected afterwards?

Perhaps it would be advisable, before proceeding to examine any witnesses, to read the section of the Act of the Legislature of Massachusetts upon the subject of a loan to the Troy and Greenfield Railroad, and the duties of the State Engineer and the Governor and Council in connection with it. I read the third section of chapter 202 of the Acts of 1860.

SECTION 3. The governor and council shall annually appoint a state engineer for the purpose of examining and determining monthly the amount and value of the work done, and materials delivered on the railroad and tunnel of the Troy and Greenfield Railroad Company, who shall receive an annual salary of one thousand dollars, payable quarterly. The state engineer shall forthwith fix permanent marks in each end of the Hoosac Tunnel, marking the progress of the work up to February twenty-fourth, eighteen hundred and sixty, from which to determine the progress subsequently made. He shall also determine by suitable notes, marks, or observations, the amount and value of all grading, bridging, masonry, or other work done, or iron, or other materials delivered on the road east of the Hoosac Tunnel prior to December twenty-second, eighteen hundred and fifty-nine, and fix data from which to determine the value of any work, or materials delivered subsequent to the date last named. He shall monthly, immediately after the first day of each month, estimate the proportion which the work done upon the road, since the preceding estimate, bears to the whole of the work required to be done in the graduation, masonry, bridging and superstructure of said railroad east of the Hoosac Tunnel, and also the work done in the excavation of said tunnel, which he shall certify separately to the governor, together with the amount of state scrip to which the company is entitled under the provisions of this act. Such monthly estimates shall be based upon a width of road-bed at grade of fifteen feet, on embankments, seventeen and a half feet in side-cuts, and twenty feet in thorough-cuts; in the heading of the tunnel, upon dimensions fourteen feet wide and six feet high in the middle, and in the finished excavation of the tunnel of fourteen feet wide and eighteen feet high in the middle.

The deliveries of scrip shall be at the rate of fifty dollars for each lineal foot of tunnel, divided between heading and full sized tunnel, in the proportion of thirty dollars for each lineal foot of heading and twenty dollars per lineal foot for the remaining excavation; and of six hundred and fifty thousand dollars for the whole of the graduation, masonry, bridging and superstructure of the unfinished portion of the road east of the tunnel.

The scrip shall be delivered on the road in the proportion which the value of the work done and the materials delivered each month bears to the estimated cost of the whole work and materials required on the portion of road aforesaid.

No expenditures shall be required merely for the purposes of ornament, but the work shall be substantially performed, and the rails shall weigh not less than fifty-six pounds to the lineal yard: for any defective materials or work, a proportionate amount of scrip shall be withheld.

The governor and council shall have a general supervision of the work, and for that purpose shall visit and inspect the same at least once in each year, and as much oftener as they may deem expedient; and they shall have power to correct abuses, remedy defects, and enforce requirements, by withholding scrip or imposing new requirements in such manner as the interest of the Commonwealth shall in their judgment require.

If the governor, upon the receipt of the monthly estimates and certificates of the state engineer, shall approve thereof, he shall transmit the same and his approval thereon to the state treasurer, and the state treasurer shall thereupon deliver the amount of scrip so certified for, to the treasurer of the Troy and Greenfield Railroad Company, or to his order, subject to the provisions hereafter mentioned. If he shall not approve thereof he shall submit the same to the council, and their approval transmitted to the state treasurer as aforesaid shall authorize such delivery.

Let me remark, gentlemen, that nothing which arises at the present time, or which is involved at this time, touches at all the Tunnel through the Hoosac Mountain. There have been opened here several questions which relate solely and exclusively to the railroad east of the Hoosac Mountain. Upon the graduation, masonry, bridging and superstructure of the unfinished portion of the road east of the Tunnel, the legislature undertakes to loan $650,000. It is this railroad, and the application of this loan, which are alone under consideration. In one word, the question is, "Has the work, in reference to the points and items suggested, been substantially performed ?"

LIST OF WITNESSES.

GEORGE BALDWIN, Civil Engineer, Boston.

JAMES LAWRIE, Civil Engineer, Brooklyn, N. Y.

JAMES P. KIRWOOD, Civil Engineer, Brooklyn, N. Y.

JOHN RUSSELL, Jr., Superintendent Portland, Saco and Portsmouth Railroad, Portland, Me.

GEORGE STARK, Superintendent Nashua and Lowell Railroad, Nashua, N.H.

E. A. CHAPIN, Superintendent Cheshire Railroad, Keene, N. H.

CHARLES RUSSELL, Road-master Western Railroad, Springfield.

E. B. PHILLIPS, Freight-master Worcester and Boston.

SAMUEL JOHNSON, Railroad Engineer of railroad extension of Old Colony to Newport.

ROBERT HARRIS, Civil Engineer, Portsmouth, N. H.

SAMUEL NOTT, Superintendent Hartford, Providence and Fishkill Railroad, Hartford, Ct.

JAMES HAYWARD, Boston.

GORDON NOTT, Civil Engineer, Boston.

MARTIN B. INCHES, Boston.

W. B. BRINSMADE, Superintendent Conn. River Railroad, Springfield.

CHARLES S. STORROW, Boston.

T. WILLIS PRATT, Engineer, employed at Gloucester and Boston.

THOMAS DOANE, Civil Engineer, Boston.

THOMAS S. WILLIAMS, Boston.

WILLIAM H. SWIFT, Boston.

WALDO HIGGINSON, Boston.

ISAAC HINCKLEY, Lowell.

ONSLOW STEARNS, President of Northern Railroad, Concord, N. H.

S. B. CUSHING, Civil Engineer, Providence, R. I.

SAMUEL ASHBURNER, Boston.

ALEXANDER HOLMES, President Old Colony Railroad, Kingston, Mass.

JOHN J. SWIFT, President Fitchburg Railroad, Boston.

ALVAH CROCKER, Fitchburg, Mass.

SEPTEMBER 21, 1861.

It is Ordered by the Governor, with the advice of the Council, that summonses issue to the foregoing witnesses to appear and testify before the Governor and Council on Tuesday next, at eleven o'clock; also, that Mr. J. M. W. Yerrinton be employed to report the testimony.

COUNCIL CHAMBER, September 21, 1861.

The foregoing Order is adopted.

CHAS. W. LOVETT, *Dep. Sec'y.*

All the gentlemen who appeared in obedience to the summons of the Governor and Council were examined; and their testimony, as well as the decision of the Governor, was reported by Mr. Yerrinton, as follows, viz.:—

Testimony of Mr. Samuel Nott.

Question.—[*By the Governor.*] Will you please to state your full name, residence, and occupation?

Answer.—My name is Samuel Nott, I live in Hartford, Conn., and am a civil engineer by profession.

Q.—How long have you pursued the profession of a civil engineer, and in what State or States?

A.—I have been engaged in it, in different capacities, for nearly thirty years. For about twenty years, in this neighborhood—Massachusetts; and in New Hampshire, to some extent, in the course of the twenty years.

Q.—What familiarity, if any, have you had with the subject of railroad construction?

A.—Well, Sir, I have been familiar with it, in different ways, from the time of which I speak. That has been my principal business.

Q.—In what capacity, and in what connection with any railroads?

A.—For a number of years from 1836, I was connected with the Eastern Railroad between here and Portsmouth, and about that time, I was engaged on the road from Portsmouth to Portland, in connection with Mr. Ashburner and Mr. Hall—the three together having charge of that road. I afterwards built the Manchester and Lawrence road.

Q.—Have you been engaged in the construction of any other railroad?

A.—Yes, Sir. I was engaged in the completion of the Portsmouth and Concord Railroad. For the last ten years, I have not been engaged in building any railroad, but I have been connected in various ways with railroads—some portion of the time making surveys for railroads. For the past four years, I have had charge of a railroad in Connecticut, as superintendent and engineer—the road from Providence west to Waterbury, 122 miles.

Q.—Will you please to state what examination, if any, you have ever made of that portion of the Troy and Greenfield Railroad lying between Greenfield and the Hoosac Mountain?

A.—I went over, last week, the whole line, generally, between Greenfield and the Tunnel. In going to the Tunnel, I saw only what could be seen by riding along, except that we stopped at a place called Stillwater, where we saw the trestle-work, and at another place up by the crossing of Deerfield River, called Bardwell's Ferry. With these exceptions, I saw only what could be seen by going along by the roads. I speak now of the trip going westerly. On the day after, I came back, and walked from Shelburne Falls to the crossing of the Deerfield River near Bardwell's Ferry. And I also walked over a portion of the road up higher, in some light work, in the neighborhood of one, two or three miles this side of the Tunnel.

Q.—Did you examine the different kinds of material?

A.—I did, so far as I could at the points I saw, and so far as I could by looking generally as I went along.

Q.—What is the character of the material from the Green River, at Greenfield, up to Stillwater?

A.—That, as far as I could judge, was a light, sandy soil.

Q.—What is the prevailing character of the earth through which the cuts are made?

A.—I should think it was a gravelly soil from Greenfield up to the points I saw. I speak now particularly of the point from Greenfield up to Stillwater—five or six or seven miles, I should judge.

Q.—What is the character of the earth from that point up to the mountain?

A.—It varies somewhat. The character of the material from Bardwell's Ferry up to Shelburne Falls is generally a compact material, some little gravel, and some clay with it, and liable to wash a good deal, I should think, from its character.

Q.—Take the embankments along the banks of the Deerfield River, from Stillwater up to the Ferry?

A.—Those I did not see. The road does not go any where near that, and that space I did not see at all—between Stillwater trestle-work and the river near Bardwell's Ferry.

Q.—Whether or not is the description of material which you observed through which the road is constructed more or less likely than other material to slide?

A.—I should say that the part I examined most critically, which is between Bardwell's Ferry and Shelburne Falls, was of a nature that would slide badly.

Q.—In what season of the year most?

A.—In the spring.

Q.—Owing to what influences?

A.—To the influence of the frost, and the water coming down.

Q.—Did you observe the character of the slopes?

A.—Yes, Sir, I did. I noticed them as well as I could. I did not make any measurements.

Q.—What criticism or observation do you consider them liable to, if any, regarded from the point of observation which you made, as an expert in railroad engineering?

A.—I think that, in going along there, without having my attention called to the thing at all, I should instantly come to the conclusion that they were too steep. I came to that conclusion, certainly, and I think that I should come to it in walking along casually.

Q.—Is that an exceptional or general criticism?

A.—General, to that portion of the road which I saw, where I had the best chance to see the slopes; and I would say the same in reference to the slopes I saw between Bardwell's Ferry proper and the river crossing just above.

Q.—What, in your judgment, should you say was the proper slope to be observed in cutting a railroad through that territory?

A.—Answering generally, I should say, not less than equal to one and a half to one.

Q.—What is the objection to the slope of one to one?

A.—It is so steep that the material is liable to slide down in large quantities.

Q.—Is that opinion the result of reading or of observation, or both, on your part?

A.—It is, generally, I might say, from observation and experience.

Q.—When was your attention first directed to questions of that sort—as to slopes?

A.—Oh, a great while ago. It was one of the first things that came up in my connection with railroads. It was a very early question in my professional experience.

Q.—Have you ever had occasion to settle it in your own mind practically? That is, to settle what slope should be given in one case and another?

A.—Yes; these questions are continually coming up, and I have had them in great numbers.

Q.—If there is any customary or usual slope, what is the slope usually observed?

A.—I should think, about here, where I know the most of the customs, that for twenty years, there has not been a road built where the rule has not been to make the slopes one and a half to one.

Q.—To what exceptions, if any, is that general rule practically subjected, by skilful engineers?

A.—I should think, generally, that the variations which are made from that rule are made to save money for the time being.

Q.—Does that observation apply to earths of all kinds?

A.—Yes; there might be very rare exceptions to it, but generally speaking, earths will require that slope in the end, and some will require more.

Q.—Now, as the result of your observation, experience and reflection of the last thirty years, is it or not your opinion that a railroad built through gravel or earth of this description would properly be called substantially constructed, its prevailing slope being found to stand at an angle of forty-five degrees, or one to one?

A.—I don't think it would be. I should not consider it so myself.

Q.—Did you observe any part of the line where the slope of one and a half to one would have been impracticable?

A.—I don't know that I did. I saw some few points where I thought there might be a doubt about that—where I felt in doubt about it; but I did not feel at all sure, one way or the other about it.

Q.—What proportion of the line did those doubts cover?

A.—Very small; very small indeed. Generally speaking, the slope of one and a half to one would be practicable, and I don't know but it would be without any exception; but I noticed points where I had some doubts about that, for small distances.

Q.—On hill sides?

A.—Yes, Sir.

Q.—Did you observe any place where the natural slope of the hill side where the railroad was located was as steep as an angle of forty-five degrees?

A.—No, Sir, I did not.

Q.—What do you think was the steepest, setting aside the rock cutting—the rocky side of the hill?

A.—I cannot give any very good estimate of that, that I know of; but I certainly did not see any thing so steep as forty-five degrees, or any thing approaching that.

Q.—If you wanted a slope of just forty-five degrees, and you were building your road along the side of a hill the angle of which was forty-five degrees, would you find it necessary to make any cut at all? I ask the question for the sake of getting an explanation upon a point on which I have been somewhat puzzled.

A.—It would depend upon the level of the road. In case the slope was such as you speak of, if you could possibly bring the level of the road to correspond, so that you would not need to cut any, then perhaps the road might judiciously be left with this natural slope. It would depend upon the level of the road-bed.

Q.—Suppose the angle of the hill was forty-five degrees, and you cut off the base of it, and left your slope just so, then the slope next above your railroad would be steeper than forty-five degrees, would it not?

A.—Yes, Sir.

Q.—Therefore, whenever a hill side of an angle of forty-five degrees is cut into, you have a slope of a sharper angle than forty-five degrees?

A.—If the road was in a cutting the slope of which was forty-five degrees, it would not come out at all.

Q.—In other words, you would not need to cut at all?

A.—It would depend upon the level of the road-bed.

Q.—Suppose you do not know what the angle of the hill is, but suppose you make a cutting with the slope of forty-five degrees, or one to one. If it is not parallel with the slope of the hill side, it will be because it is steeper than the slope of the hill side, will it not?

A.—Yes, Sir. But I thought you were supposing a case where you would still have a one to one slope—a forty-five degrees slope, and a forty-five degrees natural slope of the hill; and in that case, if there was any cutting at all, I don't see how the cutting would ever come out from the ground. So that there was some misapprehension on my part.

The GOVERNOR.—It seemed to me, that wherever you cut into a side hill, the slope made by your cutting, if it did not run out parallel with the hill itself, must necessarily be a steeper slope than the hill side, unless it is carried up to the top of the hill. In other words, if the angle of your slope is just forty-five degrees, the slope of the hill must be of an angle more acute.

WITNESS.—I don't think I understand you.

[The Governor exhibited a diagram to the witness, to illustrate his idea, which Mr. Nott examined, and then said:—]

WITNESS.—I always speak in reference to a horizontal line.

Hon. Mr. BAKER.—The Governor has had a vertical line in his mind.

WITNESS.—If the slope of the hill is forty-five degrees,—reckoning the slope in the way I speak of, from the horizontal line,—then the slope of the cut, if there is any cutting, would not run out at all. If the slope of the cut happens to coincide with the slope of the natural surface, of course they will go along together.

Q.—Did you make up any opinion as to what was the prevailing slope of the hills, on the sides of which you found this railroad constructed?

A.—I did not examine them closely enough to come to any conclusion that would enable me to give a general answer to that. I saw a good many slopes that I thought were about two feet horizontal to one vertical.

Q.—Do you know whether you found any natural slopes steeper than two to one?

A.—I don't know. My opinion is, that I did not see any that were steeper than that.

Q.—On what percentage of the line did you find the slopes of the steepest class?

A.—I should think from Bardwell's Ferry proper, up to the river crossing—something like a third or half of a mile; from there, up to Shelburne Falls. Then, in riding along the road between Shelburne Falls and Charlemont, I could see a good many slopes that seemed to me of just the same character. In looking at them from the road, they struck me as precisely like what I had seen in other places.

Q.—Will you state any reason, if there is any, why the slopes should not, or could not, have been made at an angle of one and a half to one, through all the gravel and sand parts?

A.—There is no exception to that, so far as I observed. There is no difficulty whatever in making them one and a half to one; nor, generally speaking, in making them one and a half to one in these other places I speak of.

Q.—Did you see any material along the line through which you should think the slope of one to one was proper?

A.—I don't remember any. I saw cuts where a slope of one to one would answer much better than it would in other places. In light cuts, where there was but very little accumulation of water to run into the cuts, the slope of one to one would do tolerably well, compared with other places.

Q.—In giving these opinions, do you speak taking as your standard an ideal railroad in your own mind, or the ordinary standard of well-constructed railroads in Massachusetts?

A.—I take the standard of a well-built railroad.

Q.—Do you know of any railroad where the rule of one to one, in regard to slopes, is observed?

A.—I do not. I know perfectly well, that when the Worcester Railroad was built, they varied the slopes a good deal, according to the nature of the material, or intending to be guided somewhat by the nature of the material, so that some cuts were taken out at an angle of one to one, and some one and a half to one. I speak now of the part near Boston, with which I was more particularly acquainted. And I know that they afterwards had a great deal of trouble with those cuts, and worked upon them a good deal. Although I was not connected with the work upon those cuts, still it was a thing that I knew well enough about, and saw going on, more or less, and I know that there was a great deal of trouble with all those cuts that were left at one to one; and my recollection is, that since that time, roads generally have adopted one and a half to one as the steepest, often making slopes less steep than that.

Q.—[*By Hon. Mr. Greene.*] Is it customary with railroads to finish their slopes before the roads are open for traffic and travel, or afterwards?

A.—I think it is customary, generally, to finish them before the roads are opened. There are exceptions to that, but, as a general rule, the slopes are finished before the road is opened. The exceptions, as I have already stated, are generally made on economical grounds; that is, with the idea of saving money for the time being, and spending it afterwards at some disadvantage.

Q.—Cannot the earth from the cuts be removed cheaper after the road is built and gravel trains are running, than it can before?

A.—I think not, generally speaking. There are favorable cases, no doubt, where that can be done; but generally speaking, however, it costs more to do it after the road has been opened than before.

Q.—[*By the Governor.*] Take the instance of one of those exceptional cases, as you call them, in which the slope is left to be reduced afterwards; should you or not, as an engineer, before that reduction was accomplished, consider the road as substantially constructed?

A.—I should not. One way of dealing with these exceptional cases is to cut out sufficient to make the slope, and leave it perpendicular, or nearly so, and let it come down as it will. I speak now of cases where the slope is left unfinished, at an angle of one to one, and the material left to come down and take its own slope. This explanation refers particularly to cases where particular points are left in an unfinished state, without regard to the quantity taken out.

Q.—[*By Hon. Mr. Greene.*] If you were going to build a road, should you prescribe one and a half to one as the general slope?

A.—Yes, Sir, I should.

Q.—If the natural slope of a hill was one to one, should you apply to that hill your rule of one and a half to one?

A.—No, I don't know that I should. That would be an exception, to be dealt with when it came.

Q.—Did you not see places on the Troy and Greenfield Railroad where a slope of one and a half to one would carry it a further distance than you had ever seen it on any railroad?

A.—I should think not. I don't think I saw any places where a slope of one and a half to one would carry the slope further than any I had ever seen. I saw places where it would carry the slope some distance.

Q.—What would be the relative difference between loose material,—sand or gravel,—and more compact material, as to the required steepness of the slope?

A.—What is termed compact material, I should say, would need a slope of one and a half to one, generally speaking.

Q.—Then you give no more slope than that in sand?

A.—Yes; though, generally speaking, one and a half to one is enough in sand; but there are cases where it requires more.

Q.—But if one and a half to one is enough in sand, would you prescribe the same in compact material?

A.—I should say that as gentle a slope as one and a half to one was required in all material.

Q.—Then you would apply the same slope, without any regard to the character of the material?

A.—No, Sir, I should not. I meant to say this: that I should adopt, generally, a slope of one and a half to one for hard material, and for loose material. I should make the loose material more, if it needed it, and the hard material less, if it needed it. But, generally speaking, the hard material is much more troublesome, and a slope that is barely sufficient for that would do very well for what we should consider loose material, because the loose material carries off the water better, and does not come down in such large quantities, and suddenly, as the other does; so that I should consider myself much better off with a slope that was barely sufficient in loose material, than I should with a slope barely sufficient in the other.

Q.—[*By the Governor.*] Should you consider slopes more or less exposed to washing, from their having steep hill sides above them?

A.—Generally speaking, more. The more water that can come on to a slope, the more troublesome will the slope be.

Q.—Do you know of any instance where a slope of one to one has stood without sliding?

A.—I don't remember any now. There may be cases.

Q.—[*By Hon. Mr. Ritchie.*] When you speak of never having seen a slope of one to one that has stood, you refer to loose material? You have seen hard substances stand at that angle?

A.—I speak of earths—of course excluding rocks.

Q.—[*By Hon. Mr. Greene.*] Are you acquainted with the Canal road from Northampton to Hartford?

A.—No, Sir, I have never been over it.

Q.—[*By the Governor.*] Has there been any change in reference to the construction of railroads within the last ten or fifteen years? Have those interested grown more or less careful in the matter?

A.—I should think there had been an improvement in the last ten years; that the value of good work is better understood, and that, generally speaking, work is done better than it was at one time.

Q.—On the whole, considering the observation you have given to this road, whether or not do you consider it as well finished and constructed as ordinary roads in Massachusetts?

WITNESS.—As ordinary roads are at what period of their life?

The GOVERNOR.—At the time when the road is turned over by the contractors to the corporation as a substantially constructed road, without ornament?

A.—In that form, I say, decidedly, I should not consider it such a road. I should not consider it a completed road until the slopes had been reduced. I should consider it a very important point to have the slopes reduced, and made less steep.

Q.—Did you see any natural slopes between Bardwell's Ferry and Shelburne Falls that were flatter than two to one?

A.—Oh, yes; the slopes were flatter than two to one, generally speaking.

Q.—[*By Mr. Stevenson.*] From Greenfield to Stillwater, is not the material of the slopes very good for ballasting?

A.—That is the part of the road I saw the least of, and I have not much of an opinion about it. For the first two or three miles out of Greenfield, I saw something of the line, and afterwards lost it, and did not see it again until we reached Stillwater; and I don't remember noticing the sides of the slopes along there. I noticed some trestle-work as we went on.

Q.—Can the material be better conveyed to the points where it is needed in any other way than by cars?

A.—I should think not. I should think ballasting material could be conveyed by cars better than in any other way, in many cases; but I don't know enough about the different points where the ballasting is there to speak positively.

Q.—Do you know whether there are any materials between Bardwell's Ferry and Shelburne Falls proper for ballasting?

A.—I had my mind upon rip-rapping in what I have said. I now understand the questions to refer to the gravelling of the track; and as to that, it would require more knowledge of the different points where the material would come from than I have to enable me to answer positively about it. I can only say, generally, that it would be good economy to haul by horse a long distance in preference to hauling by cars after the road is in use.

Q.—Is it customary among engineers to arbitrarily assume the slope of one and a half to one, regardless of the nature of the material?

A.—I think it is a general rule to assume that one and a half to one is the least slope that will do; and then to vary from that if there are good reasons for so doing.

Q.—What is the natural slope of the hills on the side of Deerfield River? Did you make any measurements?

A.—I did not make any measurements. I saw some that were steep, and some that were not very steep; but, as a general thing, I should think the slopes were not steeper than two to one. There may be cases where they are steeper than that; but very nearly the whole distance would be of a slope no steeper than that, in my opinion, from the observations I made as I went along.

Q.—Is it not true economy to leave the material on the sides of gravel cuts—where the cuttings exceed the embankments—to be used to fill up the ravines requiring to be filled, especially when the said ravines can otherwise only be filled by borrowing earth?

A.—Yes, I can see how that might be judiciously done in many cases.

Q.—Is not that the modern practice on the Baltimore and Ohio and Pennsylvania Central Railroads?—to make the cuts one to one?

A.—I am not aware of the custom there. I don't know what it has been.

Q.—[*By Hon. Mr. Greene.*] As far as the rails are laid and the road completed, is it or not a substantial road?

A.—I saw, of that portion of the road where the rails are laid, only a very little—not more than a third of a mile, in all. A part of that was at Greenfield, by the bridge, and a part was at Stillwater; and I caught one or two glimpses of the track as we rode along in other places. I should think, speaking generally, that even that part where the rails are laid is not what would be considered a finished road. I noticed, in one place where I saw the rails down, that the embankment was only just wide enough for the sleepers; in other places where I saw the rails laid, I noticed that the material was not good in which the rails were laid; in other places, some ditching was wanting; and things of that kind.

Q.—[*By the Governor.*] Did you observe the trestle-work over ravines?

A.—I did, Sir. I saw four or five places where that was built, perhaps more.

Q.—Did you see any objection to filling up such ravines with embankments of earth?

A.—I did not.

Q.—Any difficulty or inconvenience in obtaining material for that purpose?

A.—I think that at some places I saw, I did not see any material very near. In some places there seemed to be enough, such as it was.

Q.—Do you consider, from your personal experience as an engineer, that a railroad is properly built, is a substantially constructed road, where the ravines are trestled over, if earth could be obtained to fill them?

A.—I do not.

Q.—What has your observation been of the practice of other roads in that respect?

A.—It is not an uncommon thing to go over ravines by trestle-work, but it is never adopted if it can be avoided.

Q.—Should you consider a road finished until the ravines were filled out with a permanent embankment?

A.—I should not.

Q.—Should you or not consider trestle-work to be in the nature of a temporary or permanent construction?

A.—In such places, I should consider it a temporary affair, put up for temporary convenience.

Q.—Supposing the contract of the corporation with the contractors itself required that the trestle-work should be filled out with embankment, should you then think it possible that the railroad could be considered constructed, within the meaning of the contract, without such embankment?

A.—Clearly not, Sir.

Q.—[*By Hon. Mr. Greene.*] If the ravines were crossed by trestle-work admitted to be equal to ten years' use, would you hesitate to open the road for transportation and travel?

A.—I don't know. I might, under some circumstances, recommend the opening of the road, and the use of such structure as a temporary thing. It would depend upon circumstances.

Q.—[*By the Governor.*] Did you make any observation or examination of the bridge over the Green River, at Greenfield?

A.—Yes, Sir; I spent half an hour or an hour in looking at it and around it.

Q.—Have you any observations to make in regard to the character of that bridge, as to its substantial construction?

A.—Yes, Sir, I have an opinion about it, decidedly; and my opinion is, that I should prefer some other kind of bridge.

Q.—Is that a criticism upon the style or plan of the bridge, or is it upon the carrying out of the details?

A.—My objection to it is to the general plan.

Q.—Does that objection reach so far as to involve any doubt of its safety?

A.—Yes, it does.

Q.—In what respect do you fear it to be unsafe?

A.—On general grounds, I should always object to any bridge that has so few main points to depend on as that bridge. The main points of dependence seem to be the cylinders; and that throws the main dependence of the bridge upon a very few points; and the fewer the points, the less confidence I should have in any bridge. In the case of this bridge, the accident that occurred seems to have come from a slight mistake made by a blacksmith who did some work on the cylinders; and that occurred to me as one of the contingencies that cannot always be guarded against by the greatest amount of oversight. So that my idea would be that it would be much better to adopt some style of bridge that would be less open to such mistakes. That, in general, was my conclusion on looking at the bridge.

Q.—Would you feel safe in running a train over such a bridge, having tested it only by mathematical calculations, without the test of weight?

A.—No, Sir; I don't think I could ever be satisfied by any calculations about it.

Q.—Is that owing to the difficulty of knowing what a particular rod or support will bear, or owing to the difficulty of knowing exactly in what proportion the strain or weight will fall?

A.—It is the difficulty of knowing what proportion of the strain will come upon a particular spot; that is a part of the difficulty. The strength of the rods can be calculated with a good deal of nicety; but then, there are things which it is necessary to connect with the rods in order to develop their full strength. For instance: the nut is just as important as the bolt itself. A small mistake in the nut may spoil the whole thing. And in a new kind of bridge like that, I certainly should not be satisfied with any calculations about it. Bridges that I am used to, and which have been tried repeatedly, of course I should feel differently about.

Q.—You would not feel safe in saying that it was properly constructed, until after it had been completed, and subjected to a practical test?

A.—I should not. In the case of a bridge of this novel description, although the strain upon the different parts can be calculated pretty well, I should not feel safe until it had been tried.

Q.—Would not your apprehension be greater in regard to a structure that had been once tried, and been found in some particulars to be defective?

A.—It would, very much. I do not say that, by increasing the rods there, and by various contrivances, this bridge cannot be made strong enough for trains to pass over. I presume it can be, by some means; but it is a kind of construction that I certainly should not be willing to adopt, as I understand it now. Besides the general points that I refer to, I should object very much to its want of lateral stiffening.

Q.—Do you refer to the cross and diagonal bracing?

A.—Yes; it seems to need something more of that sort, even if there were no other objections to it.

Q.—Is there any thing else which tends to produce unsteadiness? Take the width of the bridge. It struck me as being very long in proportion to its width.

A.—It seemed to me generally as wanting in support laterally, and in security to the piers.

Q.—Is it as well secured to the piers and abutments as bridges usually are?

A.—It is, perhaps, as well secured as some kinds of bridges are. But in order that this answer may be understood, I should state that the common bridges—take the Howe bridge or the Towne bridge, for instance—merely want connecting with the piers to prevent their being blown off; that is about the sole purpose, at least, that is one of the main purposes, of the connection. But in this case, there seems to be something more than that needed—some better connection; something more than sufficient to guard against its being blown off. [Plan shown.] That appears, generally, to be the plan of the bridge.

Q.—Does not the strength of the bridge depend upon the strength and the fastening, in each particular section, of a very few rods of iron?

A.—Yes, I think it does; and ultimately it depends upon the cylinders.

Q.—Now, is it possible to be sure that you are not open to the liability to accidents, by reason of the strain or weight falling disproportionately upon one of those rods?

A.—It struck me that the bridge was quite liable to having an unequal strain upon it.

Q.—Now let me ask you if scientific men, in building a high, long bridge, which is to be subjected to the strain of a very great weight, do not mean to contrive so that if one thing fails upon which their calculations originally relied, there shall be some other resource to save the burden from falling?

A.—Yes, Sir; that is a desideratum that is always sought for, so far as I know.

The GOVERNOR. It is not enough, so it seems to me in my unenlightened state, for a man, in making a bridge, to make it strong enough to hold up a given burden, and a little more, but I think that it ought to be so constructed that in case his calculations in regard to one part failed, there should be a reserve force somewhere else to sustain the burden. For instance; if one rod breaks, there should be another rod to rely upon.

WITNESS. That is of the greatest importance, certainly. It seemed to me, too, that this bridge would be liable to a very unequal strain, owing to the winds. The wind drawing through the valley there would throw a very unequal strain on the bridge, I should think, at times.

Q.—[*By Hon. Mr. Greene.*] Did you ever see a bridge that presented so little resistance to the wind as that?

A.—I don't think I ever did. When I speak of the effect of the wind, I refer particularly to the surface presented by the cars. So far as the bridge itself is concerned, it is very favorably constructed as respects the effect of the wind upon it.

Q.—[*By the Governor.*] In what respect?

A.—It presents so little surface to the wind.

Hon. Mr. GREENE. Bridges are usually boarded up at the sides—housed, and this has nothing of that sort on it.

WITNESS. I think the surface of the cars would be sufficient to throw a very unequal strain upon one side at times; and it seemed to me, that with a bridge of so very light a character as that, any inequality of strain created in that way would be much greater even than it would be in a bridge of the ordinary kind, like Howe's, for instance. Take a deck bridge like Howe's patent, and the difference in strain made by the wind, in crossing, would be a matter of not much account, generally. With a bridge on this plan, I should think it would be a matter of some account.

Q.—[*By Mr. Stevenson.*] How long, in your opinion, will the trestle-work stand without filling, and be safe for travel?

A.—The trestle-work that I saw seemed to be strong and well put together, and I should think would last eight or ten years, with proper care. It would want more or less repairs during that time.

Q.—Did you measure any of the parts or calculate any of the strains on the Green River bridge?

A.—No, Sir, I did not. I made up my opinion on general principles entirely.

Q.—Is not Herman Haupt considered as good or better authority on bridge construction than almost any other engineer in this country?

A.—I cannot say. I have known but very little of Mr. Haupt. He is the author of a work on bridges that I have barely seen, but not for a dozen years, I should think, and I am not qualified at all to give any opinion about it.

Q.—[*By the Governor.*] Do you know whether this bridge, being on a curve rather than a straight line, is more or less exposed to danger from that cause?

A.—I think it is. I think that, generally speaking, (I don't know that there can be any exception,) a bridge is better straight than on a curve.

Q.—Did you notice the fastening of the bolts at the foot of the first posts, where the principal strain is found, and whether they are properly guarded against being drawn into the wood?

A.—I should think they were not. I noticed points where a good deal of strain would come, which it seemed to me ought to be protected by strong plates of iron, which were not strengthened in that way.

Q.—Do you consider that only two sustaining rods on the side, in a space of sixty feet, give a sufficient amount of support to guard against the contingencies following on a severe frost?

A.—I should think not.

Q.—What is the possible or probable effect of frost upon the sustaining rods?

A.—They are liable to break at such times. It increases the liability to break.

Q.—[*By Hon. Mr. Baker.*] As a practical fact, Mr. Nott, what railroad have you known completed, not delivered up by the contractor, until every slope, in earth-work, was taken out one and a half to one?

A.—I don't know that I have known of any where every single thing has been done of that kind.

Q.—Well, what one, then, of the cuts on the Eastern Railroad was taken out in that way? I happen to be somewhat familiar with that, as well as yourself.

A.—I should think, generally, they were all taken out so.

Q.—Do you remember any one particular cut? Take the one at East Boston?

A.—That is one I know less about than many of the others. The point I am most familiar with is from the neighborhood of Lynn, down some distance.

Q.—Take the cut through the Derby farm, down by Salem—I mean the gravel portion?

A.—My recollection would be, that in the gravel portion, the slopes were made one and a half to one. I do not know that I am confident about it.

Q.—Do you recollect any of the cuts in Beverly?

A.—Yes.

Q.—Do you recollect that any one of them was taken out one and a half to one?

A.—Yes, I should think they all were.

Q.—You would be surprised if I said that I had measured them, and found the slopes less than that, even after they had stood twenty years?

A.—There may be exceptions, but I believe the work generally was so done.

Q.—Then in regard to the precise material that you saw at the Ferry. Where have you seen a railroad, in this portion of the country, with similar material to that?

A.—I don't know that there is any such material about here; but it is a kind of material that I am familiar with. I don't know that I have seen any of it about here, unless the East Boston hills approach it somewhat.

Q.—Do you think that a road, to be substantially built, should be so constructed that the slopes should not wash at all?

A.—No; I think that a road might be considered substantially built, even when the slopes would wash some.

Q.—Is there any slope that you can make upon hill sides as precipitous as those are, which would not wash for twenty years?

A.—I think that, sloped in the best way they could be, they would wash more or less for a good while. On that point, my impression is this, exactly—that if these slopes are reduced to one and a half to one, they will wash some; if left as they are, they will wash a great deal, and very heavy masses will come down.

Q.—Will not heavy masses come down with the slopes one and a half to one?

A.—I have known cases where large masses came down when the slopes were one and a half to one; but, comparing like things with like things, I should say, decidedly, that the one and a half to one slope would have the preference.

Q.—So far, then, as there may be any consistency among engineers, is it not a fact, that one and a half to one is the maximum rule in reference to all sorts of material, and that it is varied according to circumstances? Is not that the practical fact in the operation of the rule?

A.—Yes, that is what I have stated. I meant to state, that one and a half to one was generally adopted as the slope of least steepness. That is varied from in particular cases—sometimes made less steep, sometimes left more steep, in exceptional cases.

Q.—Is it your judgment that the sides of the county road we rode over the other day—the artificial slopes in the side hill—are one and a half to one?

A.—I should think they were not. I should think they were steeper than one and a half to one, some of them.

Q.—They were supported more or less by the growth on the side hill, by the projecting rocks, and so on?

A.—They had considerable support of that kind, but I was satisfied there would be a good deal of trouble with those slopes hereafter; that they would want flattening out and working over a good deal.

Q.—Is there a railroad in the country complete in that sense, or do they all have to be worked upon, and the ditches dug out to remove the wash from the slopes?

A.—Yes; but, as a general thing, I think this is a safe statement—the less inclination of slope, the less wash; and the reverse is true, in all kinds of earths.

Q.—[*By the Governor.*] In other words, I suppose that in building a railroad, the slope to be given is not to be regarded like the solution of a mathematical problem, but there is a general rule, from which rule you have deviations and exceptions. The object is to find some rule that will, in general, give you the best working slope?

A.—That has been the object. We want to find, practically, the best working slope.

Q.—That you call one and a half to one?

A.—Generally.

Q.—[*By Hon. Mr. Baker.*] That I understand to be the maximum slope. What do you mean when you say "maximum slope"?

A.—I don't think I have used the word, Sir. I have been very particular to keep that distinction clear, or intended to be. I speak of a slope with reference always to the horizontal line. A maximum slope would be a steep one—steeper than a minimum slope, to me; and I have endeavored to keep that distinction up.

Q.—What I mean is, whether one and a half to one is the extreme slope required in any case?

A.—I don't say that now. I said that one and a half to one is the general rule adopted; that sometimes the general rule is departed from by making the slope two to one, for instance, or three to one, if you please—which is making it flatter. In some other cases, it is judicious to depart from it in the other way—to make the slope steeper, owing to some peculiarity of the case, want of room, for instance, or something like that; so that nobody, as far as I know, who has any skill in these things, adheres to the rule blindly. It is intended to adhere to it as far as it should be adhered to, and to depart from it when it should be departed from. But, as a general thing, every body, so far as I know, finds it judicious to adhere to that degree of slope—one and a half to one.

Q.—But there is no railroad that you know of that was absolutely completed in that style before it was given to the corporation?

A.—I don't know that there is any one that has been entirely finished in that style.

Q.—[*By Hon. Mr. Hayden.*] I would like to ask whether you ascertained how near the rails would be laid to the base of those slopes in all cases?

A.—No, Sir, I did not. There was a little difficulty in forming an opinion in most places, but generally I could tell by comparing the case with something else that I saw that I supposed was right; but in two or three cases, I was in some doubt about that.

Q.—Suppose the track was to be laid twenty feet from the base of the slope, can you tell what degree of inclination the slope would take before it would interfere with the rails or the track?

A.—No; it would depend upon the vertical depth of the cutting.

Q.—Did you ascertain in how many instances the track was intended to be laid from twenty to thirty feet from the base of the slopes?

A.—I am confident I did not see any place where I thought the track would come so much as twenty feet from the foot of the slope. I saw some places where I was in doubt about the distance, but no place where I was in so much doubt as that.

Q.—If twenty feet, you would not consider it necessary to bring the slope down to one and a half to one?

A.—That would depend altogether upon the height of the cutting.

Q.—Take the case of a twenty foot cutting, for instance, and that cutting sloped one to one, the foot of that slope being twenty feet from the rails?

A.—Whenever that was brought down to one and a half to one, I should not think that the slope would come down any where near the rails, with that depth of cutting. All such questions depend entirely upon the depth of the cutting.

Q.—Then it would be necessary to ascertain how near the rails would be laid to the base?

A.—Yes, to form a nice opinion about it.

Q.—[*By Hon. Mr. Greene.*] Was your examination of that bridge so thorough as to enable you to give an intelligent opinion as to its strength—one that you would feel satisfied yourself was an intelligent opinion?

A.—Yes; I feel well competent to judge, as far as I can judge myself about it.

Q.—Is there or not a formula by which engineers calculate the strength of bridges?

A.—Yes; there are ways of calculating the strength of bridges.

Q.—Supposing a competent engineer should tell you that he had calculated the strength of that bridge over the Green River, and that it would bear thirty times the weight likely to be put upon it, and it was afterwards subjected to the test of actual weight, would you not consider it a safe bridge then?

A.—I don't know. I should doubt it.

Q.—Should you consider your observation, for thirty minutes, of a bridge of that size, equal to the scientific calculations of a competent engineer of its strength?

A.—Until it was very thoroughly tested, I should depend upon my own opinion about it, rather than upon any calculations.

Q.—Were all these faults the result of your own observation, or were they suggested to you?

A.—Most of them I thought of myself.

Q.—Were any of them suggested to you?

A.—Yes, Mr. Whitwell pointed out some of them. On the main points, I had an opinion very soon myself, entirely of my own motion.

Q.—Mr. Whitwell invited you to go up on that occasion?

A.—Yes, Sir, he did.

Q.—Did you have any conversation with him in relation to the character of the road?

A.—No, Sir. I saw him here in Boston, and he said something about it, but we had no conversation in regard to it.

Q.—Did he know your opinion as to what slopes were requisite?

A.—Yes, Sir. On general principles, I had told him what my opinion was about slopes.

Q.—[*By the Governor.*] Do you know any other engineer whose opinion differs from yours in that respect?

A.—I do not. I don't mean to say, in regard to the bridge, but that I might be convinced of its safety, but I certainly should need a good deal to convince me. I cannot conceive of any amount of calculation that would convince me, and it would require a good deal of use of the bridge to do it. That is the way the thing stands in my mind.

Q.—[*By Hon. Mr. Baker.*] Is there any rule, Mr. Nott, as to the sloping of embankments?

A.—Yes, they are generally laid out to be a foot and a half to one, and so constructed generally, I think.

Q.—[*By Hon. Mr. Ritchie.*] Suppose there was wash down the hill, would it matter much what the slope was in regard to the fall of material down? I noticed that many of the hills rose up very high and had trees upon them, and in some places trees had fallen down upon the track. What difference would it make, in regard to the fall of trees, rocks, or any thing of that kind, whether the slope was twice as great or half as great? I noticed that at the top, where the hill joins the cutting, the earth hangs over, and trees, in many cases, with their roots.

A.—Yes; trees will hang over in such cases, held by the roots, and will stay so some time. If I understand your question right, my answer would be this: that, generally, the steeper the slope, the more stuff, of all kinds, comes down; and the less steep it is, the less stuff comes down.

Q.—The point is this: supposing you have a cut down a side hill eight or ten feet, you cannot slope that cutting into the hill very much. Supposing you slope it very little, or slope it a little more, what difference is it going to make with the wash from the mountain above whether it finds the slope greater or less?

A.—On that point my answer would be the same, precisely: that the steeper the artificial slope is, the more it will be disturbed by the water and other things coming down from above.

Testimony of Mr. Isaac Hinckley.

Question.—[*By the Governor.*] What is your profession, Mr. Hinckley?

Answer.—I cannot say that I have any profession. I am engaged in the cotton manufacture.

Q.—Have you had any railway experience, either in the construction, or management, or running of railroads?

A.—Many years ago, I was superintendent of the Providence and Worcester Railroad for a few years. I have no connection with any railroad now, except that I am a Director of the Boston and Lowell Road.

Q.—In your capacity as superintendent of the Providence and Worcester Road, did you at any time have occasion to examine or consider the question in regard to the proper slope for railroad cuttings?

A.—We were a good deal troubled by slides, which obstructed the business of the road.

Q.—Did your observation on that subject lead you to form any opinion as to the angle that it was desirable should be observed?

A.—I always prayed most fervently that the engineers would make their slopes less steep. I really cannot tell whether we had any slopes as steep as one to one. The engineer who built the Providence and Worcester Road, Mr. Pratt, is here.

Q.—Didn't you find any of the slopes that did not slide?

A.—We found some slopes that were sufficiently flat; that is, that did not slide at all. Mostly, they were sand and gravel; but we had other slopes, where we had clay, or marl, perhaps, that used to slide badly. As a general thing, the sandy slopes stood very well on that road. We had some very deep cuts.

Testimony of Mr. T. Willis Pratt.

Question.—[*By the Governor.*] Where do you reside, Mr. Pratt, and what is your profession?

Answer.—I reside in Plainfield, Connecticut. I am a railroad engineer by profession.

Q.—How long have you been a civil engineer, and what experience have you had in the construction of railroads?

A.—I commenced the practice of engineering on the Dry Dock in Charlestown, in the year 1828.

Q.—What experience have you had in building or managing railroads?

A.—I was assistant-engineer of the Boston and Lowell Railroad, the Norwich and Worcester Railroad, and chief-engineer of the Providence and Worcester Railroad; I was chief-engineer and superintendent of the Hartford, New Haven and Springfield Railroad.

Q.—Then your professional life has been devoted to railroad business?

A.—Yes, Sir, excepting a short time on the Dry Dock.

Q.—What is the usual slope observed in the construction of the cuttings on a well-built railroad?

A.—I have never used any other than one and a half to one, except in one instance.

Q.—What was that?

A.—On the Norwich and Worcester Railroad, when I was assistant-engineer, I was by directed the chief-engineer to slope two cuts on that road one and a fifth to one. The result was, that when we came to lay the rails, we had barely room to do it, the earth had run down so much.

Q.—What is the character of that material?

A.—Rather a compact gravel, hard, and he supposed it might stand at that angle. We had trouble with it afterwards, and had to put on a gravel train to clean out the cuts. I was superintendent of the road after it was done. The slopes of the Providence and Worcester Railroad are in the specifications noted as one and a half to one, except the rock. There were several instances where the contractors failed to complete the work and left it, and in those instances, the slopes were left unfinished. If the contractors had gone on and completed their contract, they would have been required to finish those cuts one and a half to one.

Q.—Have you ever found, in your own experience, that the slope of one and a half to one was too steep?—that it ought to have been one and three-quarters or two to one, for example?

A.—One or two instances have come under my observation. One is on the Worcester Railroad. We had a clay cut at Hartford, also, that would not stand one and a half to one. It would stand in the summer season, in dry time, but the frosts would affect it, and it would run. The instance on the Worcester Railroad was at Cutler's Summit, where it was reduced afterwards to two to one.

Q.—Has the general professional mind among engineers arrived at the adoption of any general rule in reference to slopes?

A.—So far as I know, Sir, it has always been stated as one and a half to one, in all earth cuttings. Sometimes, there is a species of rock, cemented gravel, or a mixture of gravel and rock, which is allowed less slope.

Q.—How far should you, as a practical engineer, say that a road constructed through territory like that described by Mr. Nott just now, could be regarded as a substantially constructed road, with the slopes left, as a rule, at the rate of one to one?

A.—I don't know that I have the right idea of what Mr. Nott described that road to be; but I don't think any thing is substantial that is left to tumble down afterwards.

Q.—Do you know any territory in Massachusetts through which a railroad a dozen miles long could be built and regarded as a substantially constructed road, with the slopes left at that angle?

A.—No, Sir, I do not. My experience has mainly been in the direction I tell you—in the south part of Massachusetts, Connecticut and Rhode Island. I have been over some lines of road in the other direction, but I cannot say that I have observed the material.

Q.—Do you know whether this rule is one about which the professional mind has any doubt, and varies upon, one way or the other?

A.—I have never had any doubt, and in conversation with others, I do not know that I have heard them express any difference of opinion. Whenever it has been changed, it has been changed for a temporary purpose, in order to hasten the laying of the rails, so that the road could be opened to traffic. In certain cases, that has been done, for a temporary purpose.

Q.—What experience have you had, practically, in the science of bridge building?

A.—At one time, I devoted a good deal of time to investigating the problems relating to the strength of bridges.

Q.—Have you built many bridges?

A.—I have made the plans for them, and had them built under my direction. I have never built any as contractor.

Q.—Have you ever seen this bridge over the Green River?

A.—No, Sir, I never have been there.

Q.—Do you know what the principle or plan is upon which that bridge is built? Have you ever seen it or heard it described?

A.—I have never seen any thing but that sketch of it [alluding to a sketch of the profile and elevation of one span.]

Q.—Does that sketch enable you to understand the principle or plan?

A.—So far as the vertical strength is concerned, I can judge from this. There is nothing here that shows any lateral bracing, or any thing to prevent the side action of the wind, or the action of the train laterally.

Q.—Is there any criticism that you would make upon that?

A.—Such a bridge can be made strong enough to carry any load over it by bracing, and understanding how to proportion the strength of it.

Q.—Take the bridge just as it lies there delineated on paper. Is that a sufficient means to enable you to give any opinion?

A.—Well, Sir, I could construct it to carry any load which a railroad train could carry over it.

Q.—But whether that is sufficient to do so, can you say?

A.—No, Sir; there is no detail here of dimensions. It can be made laterally strong enough. There is no trouble about that. If there was any defect, it would be a defect in some of the material. I will make this observation; that with regard to these points that are drawn as circles, I understood Mr. Nott to call them cylinders. I cannot understand how the bolt is put into the cylinders, or how they are fastened.

Hon. Mr. AMES. The nuts are on the inside, pulling outward.

WITNESS. If the nuts are pulling outwards, the cast-iron is subjected to a tensile strain, which is the very worst strain to which cast-iron can be subjected, unless there is a very large weight of it. But even then, with proper rules for calculating it, it can be made strong enough in that way. Whether it is strong enough in that way, I cannot say.

Q.—[*By Mr. Whitwell.*] Would you consider it proper to use cast-iron there?

A.—Not with a strain to pull it apart; but with a compressing strain, I should. There are none of these structures any stronger than their weakest part.

Q.—[*By the Governor.*] If one of those rods should happen to snap, what is there to hold on by and save the burden from falling?

A.—If one of the main rods should break, the bridge would come down, and all there was on it. A small rod might break, and the bridge still stand.

Q.—[*By Mr. Whitwell.*] Would you not consider it necessary to have the bridge very thoroughly diagonally braced, especially upon the curve?

A.—Certainly; that is an observation I made. I spoke of the diagonal vertical bracing, and also of the lateral horizontal bracing. That ought to be very thoroughly taken care of, to prevent the action of the train in going over it. There are other plans which I should prefer to this. This is what I should call a skeleton plan. There is not weight enough to it. Still, I could make it strong enough. The great difficulty is, there is not weight enough to the bridge, in comparison with the weight that goes over it.

Q.—In what way should it be filled out to give it the proper strength?

A.—I should rather fill it by filling in a chord of timber (stringers) from abutment to abutment. That is not absolutely essential, but still, it gives much more weight, and does away with some of the lateral vibration—gives the bridge more stiffness. Still, as the plan is, it may be made strong enough.

Q.—[*By the Governor.*] Do you mean by the addition of new features, or by taking care that the materials, according to the plan there delineated, shall be very perfect?

A.—I speak of these matters comparatively. One thing may be very good, and another may be a little better by adding something to it. If a train should run off the track on the side of the bridge, the bridge would be broken down by the weight of it. Some piece of timber or brace would break, and the whole bridge would go down. The same may be said of many other bridges in use; but where there is greater bulk, there is more chance of safety.

Q.—Built on precisely that plan, should you call it a substantially constructed bridge or not?

A.—It depends entirely upon the amount of material in it, which I am not able to give. It is a very easy matter to determine the strength of each of these parts, and to determine that no part shall be overloaded. If that is done, the bridge will be safe.

Q.—[*By Mr. Whitwell.*] Would you not be obliged to put wrought iron into it, on account of its being so light?

A.—I should not overload the iron per square inch. When it is not overloaded, it is safe enough. After that is done, I should want more bulk in the bridge, so as to have the weight of the bridge compare in some measure with the weight that goes over it.

Q.—Do you like this plan as well as other bridges?

A.—The principle is the same as mine. I should prefer mine to this, because it is more simple, and more easily put together. I should prefer Howe's bridge to this, myself. Still, I don't mean to say this cannot be made strong enough. I think it can.

Q.—[*By Hon. Mr. Hayden.*] Do you mean to be understood as saying that the strength of that bridge depends upon its weight?

A.—No; I mean the lateral vibration, the jar, is dependent a good deal upon its weight.

Q.—[*By Mr. Whitwell.*] Why would you prefer Howe's plan, or your own, to that?

A.—I think they are more capable of being made by ordinary mechanics, and therefore it is safer to trust them to ordinary mechanics to be put up. They are more easily put up, and when up, they weigh more, and are better.

Q.—Is there not more difficulty in regard to the details of that plan than Howe's?

A.—That is so crude that I can hardly tell what the details are. All I have gathered is from what Mr. Nott has stated in regard to the cast-iron cylinders, the rods, &c.

Q.—[*By Hon. Mr. Hayden.*] How thick had the iron in those cylinders ought to be, if they are made of wrought iron?

A.—That would require a careful calculation, and I cannot answer it off hand. We assume that a bridge is to carry about one ton to a foot. Generally, we find that the weight of a bridge is a little less than the weight of the train.

Q.—How many times the weight of the train ought a bridge to be able to sustain?

A.—I think there ought not to be a greater strain brought on the iron than five tons to the square inch. That is about one-fifth the strength of the best iron—twenty-five tons to the inch. To the wooden part of a bridge, we generally allow about eight hundred pounds to the square inch; and when we don't load the material above that, we consider the bridge permanent.

Q.—[*By Mr. Whitwell.*] Would you put any diagonal vertical bracing over the piers?

A.—Certainly I should.

Mr. WHITWELL.—There is none there.

WITNESS.—I did not know that fact.

Q.—[*By Mr. Whitwell.*] Would you put any lateral horizontal bracing on the lower part of the bridge?

A.—Certainly.

Mr. WHITWELL.—I think there is no lateral bracing. There are posts which are connected together by cross-ties, but there is no lateral bracing.

Q.—[*By Mr. Whitwell.*] Should you consider it safe to put the nuts on the bolts that pass through the timber at the foot of the posts without plates to prevent their being drawn into the wood?

A.—That depends upon the amount of lateral strain brought to bear upon the timber. In that case, I should not compress the timber more than two hundred pounds to the square inch. If the timber is overloaded laterally, it will fail as quickly as when overloaded any other way. In making a bridge, it is necessary to calculate the proportions of all the bearing surfaces.

It is necessary to calculate every thing about it, in order to make the structure perfect.

Mr. WHITWELL.—These bolts I speak of are the bolts that run from the suspension rods to the foot of the posts.

WITNESS.—Whatever they are, their strength can be calculated.

Q.—[*By Hon. Mr. Ritchie.*] If the strain is very great, would you have washers under the nuts?

A.—I certainly should. We generally make the washer five times the size of the bolt, when it is pressed against the lateral surface of the wood. It is easy to force an ordinary washer right into the wood; but if the washer is five times the diameter of the bolt, it will stand very well.

Q.—[*By Hon. Mr. Ritchie.*] Could not such a bridge as the one described be made steady enough for a train by planking down?

A.—I think not, Sir. If a good lateral bracing was given to the bridge, it might be strong enough.

Q.—Would any strain come upon the stringers you speak of?

A.—Those stringers could be used, and additional lateral bracing put in, and that gives them stiffness, besides adding to the weight of the bridge.

Q.—Would you consider the bridge safe without lateral bracing?

A.—I said before, it might be made safe. If the bridge had considerable lateral motion to it, I suppose a train could be run over it. The moment it was found that it had considerable lateral motion, there would be an order given that the trains should run slowly over it. There are a great many bridges which trains do not cross at a rate of more than ten miles an hour.

Q.—Don't you think the bridge is exposed to more lateral motion from being on a curve than it would be if on a straight line?

A.—Undoubtedly. However, that is comparative, as regards the rate of speed.

Q.—[*By the Governor.*] I believe you were invited to go up and see this road, were you not?

A.—I was. I have charge of the Rockport Railroad, on which the contractor was just about completing his work, and I was required to be there at that time.

Q.—Do you consider a railway to be substantially constructed before the trestle-work over ravines has been filled up with embanking?

A.—I presume trestle-work is used for the purpose of hurrying the laying of the rails, so as to get the road opened without expending all the money. Such things have been done.

Q.—Then you regard it as temporary, not permanent?

A.—I should regard it as temporary. I should not recommend it, except to save money. I recommended it on the New York and Boston Railroad—the Air Line—where the trestle-work cost four dollars a linear foot, and the embankment eight. I should expect it to be filled up afterwards. I should not allow a contractor to do that, unless he had some special arrangement with the company.

TESTIMONY OF CAPT. WILLIAM H. SWIFT.

Question.—[*By the Governor.*] What is your profession, Captain Swift?

Answer.—I am a civil engineer by profession.

Q.—Will you be kind enough to state the extent and variety of your experience as an engineer on railroads, or having charge of railroads?

A.—My principal employment was upon the Western Railroad, here in Massachusetts, from 1836 to 1840. I was superintending and resident engineer in the location and construction of that road.

Q.—Have you, since that time, had any connection with railroads?

A.—I have, as president of the Wilmington road and of the Western road—three years in one position, and four in the other.

Q.—Are you enabled, from your observation, experience and study as an engineer, to state any general rule adopted as the rate of slope appropriate to railroad cuttings?

A.—The object is to get as nearly as possible the natural slope of the particular earth you are working. One and a half to one, here in New England, has generally been considered the proper slope for railroad cuttings, so far as I know. It was the slope prescribed in the construction of the Western Railroad, twenty years ago, and I don't know that it has been varied since.

Q.—That you consider to be the general rule?

A.—Yes, Sir. There is certain earth that will stand one to one—stiff clay—but how long I cannot say.

Q.—You mean what we commonly call blue clay?

A.—Yes, Sir; any stiff, tenacious clay. There are other earths that will not stand one to one, or two to one. We have instances on the Western road where the earth is washed down as flat as four to one, and I don't know but five. That is where there is a mixture of sand and clay, hard pan, and every thing of that sort.

Q.—Do you consider trestle-work across ravines permanent or temporary structures?

A.—Temporary. It is frequently resorted to, to expedite the opening of a road, and may be made perfectly strong for a time; but still, I regard it as temporary work.

Q.—Not a substantial construction of the road, but a temporary expedient?

A.—Not so considered, but temporary.

Q.—[*By Hon. Mr. Baker.*] Is it the custom, where trestle-work is built, to allow the contractors to fill it up, after the road is opened, or is it done by the road?

A.—No, Sir; it is done by the road, on the principle of not allowing any body to come upon the road. The company would do it, at such times as suited their own convenience.

Q.—Would it not be chargeable to the construction account?

A.—That would depend upon the contract. Frequently, a company takes the work out of the hands of the contractors, and fills it up itself. Ordinarily, contracts are made to build a mile, or ten miles, of railroad,—to form the banks and make the cuts; and they are supposed to be made perfect—one and a half to one, if that is the prescribed slope; and if there is any thing to prevent that, of course, if it is done by the company, it is at the charge of the contractor.

Q.—[*By Hon. Mr. Ritchie.*] Have you been over the line of this Troy and Greenfield Railroad?

A.—I never have.

Q.—[*By Mr. Whitwell.*] Should you consider the road as substantially built until the trestle-work was filled up?

A.—I should not.

Q.—Should you consider it finished before that?

A.—I should not.

Q.—What slope would you give to hard pan?

A.—Well, unless it is very hard, the idea would be to take as little off as possible, and finally it will take its natural slope.

Q.—Do you think it would stand at a steeper slope than one and a half to one, after standing a year or two?

A.—No, Sir, not any length of time.

Q.—What should you prefer for convenience of taking out, and leaving with a steep slope, hard pan, clay, or gravel?

A.—Clay; but only for a temporary purpose. The general answer is, that a slope of one and a half to one is usually required. Indeed, in Europe, it is two to one.

Q.—[*By the Governor.*] Is that owing to the greater caution exercised, or to a difference in the material?

A.—Perhaps to a difference in the material. It was adopted in England, where there is a great deal of clay cutting.

Q.—[*By Mr. Whitwell.*] In running a road, which gives the most trouble, the clay cuttings or the gravel?

A.—The clay.

Q.—Which slides most, the clay or the gravel?

A.—The slides from the clay are the most, and the more dangerous, in fact, because they come down in masses, while with the gravel, there is a gradual dribbling.

Q.—[*By the Governor.*] Is it more expensive to reduce the slopes after a road has been put in operation than before?

A.—Yes, Sir.

Q.—Is it customary to require a contractor to finish a road completely, so far as regards the reduction of the slopes?

A.—Yes, Sir, so far as my experience goes.

Q.—[*By Mr. Whitwell.*] Is the running of a gravel train, after the road is in operation, a material inconvenience?

A.—A very material inconvenience, particularly in case there is but one track, as we have found on the Western road, because a breakdown, or any thing of that sort, interrupts the whole business of the road.

Q.—Do not the freight and passenger trains running over a road increase the cost of running a gravel train?

A.—Oh, yes; you are limited as to the time when you can do the work, and are obliged to resort to night work.

Q.—[*By the Governor.*] You have not command of the track, in other words?

A.—No, Sir.

Q.—[*By Mr. Whitwell.*] Do you think there has been any material change in the method of constructing roads within the last ten or fifteen years? Are they constructed in a better manner?

A.—I think the tendency is to require better work and better materials, where there is the option. In some cases, it is necessary to open a road as soon as possible, and as little earth is taken out as can be got along with, that the company may get the cars running and receive the income from the road.

Q.—Have you known of cases where poor masonry has been taken out and replaced by better?

A.—Certainly.

Q.—Do I understand you, that where a wall falls down, or an abutment, it is replaced by better work?

A.—It is, certainly.

Q.—[*By Hon. Mr. Greene.*] Is there as much costly masonry—cut-stone masonry—used now as formerly?

A.—I think there is more.

Q.—Is it customary now to have cut-stone masonry?

A.—It is, as far as I can say of the roads I travel over, customary to have cut-stone masonry, and much better work.

Q.—[*By Mr. Whitwell.*] Have you examined the plan of the Green River bridge, and can you give any opinion in regard to it?

A.—No, Sir; I never have seen exactly such a bridge; but, as Mr. Pratt remarked, it is a sort of bridge that can be made strong enough if the materials are properly disposed and enough of them. Whether the plan is judicious or not, I do not attempt to say, because I have never seen such a bridge.

TESTIMONY OF MR. ROBERT HARRIS.

Question.—[*By the Governor.*] You are a civil engineer by profession?

Answer.—Yes, Sir.

Q.—How long have you pursued the profession?

A.—Since 1848—thirteen years; for the first four, here; eight years in the West; the last year, in Texas.

Q.—During that time, have you been occupied in railroad construction or management?

A.—For the last ten years, I have been engaged in railroad construction; previous to that, as an assistant.

Q.—What is your opinion, and what is the result of your experience as a railroad engineer, of the proper slope to be observed in a railroad cutting?

A.—As a rule, I have always adopted the practice of one and a half to one. That is the universal custom in the West, where the principal part of my business has been, and where the soil is very much of the same general character as here.

Q.—Whether or not you consider a railway to be substantially constructed, if the general rule observed in making the cuts is only one to one?

A.—I should not, under ordinary circumstances. Each special instance would be its own law where it differed from one and a half to one.

Q.—Then it would only be an exceptional case?

A.—Yes. That is, there might be a whole road of thirty miles, where the circumstances would be such that it would not be necessary to have so steep a slope as that; but I should start with that, and differ from it as circumstances required.

Q.—Have you ever seen any earth where that slope was not required?

A.—No, Sir, except in the Southern country, where they have no frosts to throw the earth down. A steeper slope might be adopted there, on account of that difference.

Q.—Is it your opinion that the reduction of the slopes after the road has been put into operation is more expensive than before?

A.—That has been my experience, from the loss of time in running the trains and the inconvenience we labor under in doing it in that way.

Q.—Do you consider trestle-work over ravines to be a substantial or permanent, or only a temporary construction.

A.—My own opinion in reference to that accords with the general practice. Any one familiar with the Buffalo road will remember many instances where they had high trestle-work, which has been renewed since 1853. Trestle-work is permanent only in a certain sense. If it is wood, it will decay in time. The trestle-work on the road I speak of has been replaced by deck bridges with stone abutments. The trestle-work was originally adopted for the purpose of getting over the ground as quickly as possible. The question whether it is permanent depends, to my mind, on whether it is intended that that shall be the way in which it is eventually to stand.

Q.—Supposing the contract requires of the builder that the trestle-work shall be made solid?

A.—That would settle it in my mind, that it was not to be regarded as a permanent structure for that road.

Q.—Is trestle-work used here in Massachusetts as a permanent structure?

A.—Not upon first-class roads, that I know of.

Q.—[*By Hon. Mr. Greene.*] Are you acquainted with the Canal road from Northampton to Hartford?

A.—No, Sir, I am not.

Q.—[*By Hon. Mr. Ritchie.*] When you speak of a road being substantially made, do you have any reference to the slopes?

A.—My idea of a substantially made road is to make it as you are going to continue to use it, with the exception of the changes made necessary by decay. Iron will wear out, and timber will rot.

Q.—[*By Mr. Whitwell.*] Was this trestle-work to which you have referred over large ravines?

A.—On the Southern and Lake Shore Railroad they are not over gorges, or what you call ravines, but small rivers and creeks. The material there is very different from here.

Q.—Should you think of using trestles over ravines in side hills, not more than three or four hundred feet across, and not more than forty feet in depth, where material was at hand for filling?

A.—No, Sir; I should think it very dangerous to use them, because of their liability to wash out; and where there is material to be had, I should fill them up.

TESTIMONY OF MR. CHARLES S. STORROW.

Question.—[*By the Governor.*] You are a civil engineer?

Answer.—I am.

Q.—Have you had any thing to do with the construction and management of railroads?

A.—I had some years ago; I have not for the last fifteen years. I was closely connected with the Boston and Lowell Railroad as engineer and manager of the road, for some time.

Q.—You mean, as engineer in the construction of the road?

A.—Yes, Sir; and as manager eight or ten years afterwards. For the last fifteen years, I have had charge of the works at Lawrence,—the construction and care and management of them.

Q.—What is the rule touching the proper angle to be given to the slope in a railroad cutting?

A.—As far as my knowledge goes, it is one and a half to one. That was the slope adopted on the Lowell Railroad, and at that time, I believe it was adopted on all the New England railroads. In making the estimates of what is to be done in building a new road, almost as a matter of course, engineers adopt that rule, subject to modifications according to the nature of particular localities. On the Lowell Railroad, we adopted that; but there were some cases where it had to be made flatter—two horizontal to one perpendicular.

Q.—Are there many exceptions to the rule that requires the slope to be as flat as one and a half to one?

A.—No, Sir. I should say it would be an exceptional case.

Q.—Whether an exceptional case of frequent or infrequent occurrence?

A.—Infrequent.

Q.—Should you consider a road substantially constructed, if the slope is left steeper than one and a half to one, as a rule?

A.—No, Sir, I should not.

Q.—Supposing that the road, where it crosses ravines, is left with the trestle-work standing, not filled up with earth embankment, should you consider the road in that respect as substantially constructed?

A.—No, Sir, I should not, because earth-work becomes stronger by time, and timber-work becomes weaker.

Q.—Can the reduction of the slopes be done more or less cheaply after the road has gone into operation?

A.—It depends something upon the character of the traffic—whether more or less use was made of the road for passengers and traffic. As a general thing, I should say all that ought to be done in advance—that is, before the road is finished.

Q.—Supposing it is a great line for traffic and travel—for freight and passengers, so important and so large as to demand the tunnelling of a mountain five miles through, and you have but a single-track railroad—should you think it probable that the expense of reducing the slopes would be as little after the line was opened to business as before?

A.—I should think it would be greater. The delay and inconvenience to the gravel train would be increased, the delays and inconvenience to the passenger and freight trains would be very great, and the risk of accidents would be increased.

Q.—How is it with regard to filling up trestle-work afterwards?

A.—That can well be done by cars. For my own part, I should prefer to use cars over such portions of the road as are finished, and fill it up before opening the road for traffic.

Q.—Does the character of railway work (I mean, the materials and the work employed in the construction of railways) improve or does it deteriorate with the progress of railway science?

A.—As far as my observation and experience go, it improves. I know of many railroads where work has been taken down and replaced by better. That was the case on the Lowell Railroad. Bridges that had been built like rustic fences, almost, were taken down and rebuilt with split stone. That was done after the road was completed. It would have been much better to have had it done before.

Q.—Have you had charge of any other railroad?

A.—No, Sir.

TESTIMONY OF MR. JAMES HAYWARD.

Question.—[*By the Governor.*] I think you built the Boston and Maine Railroad, did you not?

Answer.—Mainly; it was commenced before I went down there.

Q.—And what other roads?

A.—I have not finished any other road, but I have made surveys for other roads, and superintended some of the other work.

Q.—What rule for the slopes in railroad cuttings have you observed?

A.—We adopted early, as the general rule for slopes, one and a half to one. We have had some few instances which did not seem to require that, and we attempted something a little less. But that seemed to be, generally, a convenient slope to stake beforehand.

Q.—Did you not survey and locate the road from Rouses' Point to Ogdensburg?

A.—Yes, Sir.

Q.—Did you adopt there the slope of one and half to one?

A.—I think I did, in all that was staked out. I left before the eastern portion was staked out for the contractors.

Q.—Have you ever surveyed a road where you adopted any other rule?

A.—No, Sir.

Q.—How long since you adopted the profession of railroad engineer?

A.—I made the preliminary surveys for the road from Providence to Boston in 1827. That was my first experience.

Q.—In crossing ravines, what has been your rule, to consider trestle-work as a permanent and substantial construction, or fill it up with embankment?

A.—I have never adopted trestle-work instead of embankment, where there was not to be a bridge. The Ogdensburg road had, when opened for use, half a mile of trestle-work upon it. It was not made by my particular recommendation, but it was adopted after I left. They found it was difficult to get the material to make an embankment, without going some distance, and they adopted trestle-work; but I believe it has been filled up since. Two roads that I have had something to do with have had trestle-work put in, that was subsequently filled up with earth. The Portland, Saco and Portsmouth Railroad is one of them. There were two places on that road—making together a distance of a third or half a mile—where trestle-work was built, and used about twenty years. We filled up the last a year ago this last summer. That, I believe, was over a quarter of a mile in length. The Cocheco road, which is connected with the Boston and Maine, where a good deal of my experience has been gained, was opened for use with two valleys filled with trestle-work. I should think they were four or five hundred feet each, without knowing exactly. That road has been running, in connection with the Boston and Maine Railroad, ten or twelve years, I should think, and they are still standing.

Q.—Where the contract made between the corporation and the contractors required that any trestle-work or temporary bridging used in the construction of the road should be changed by and at the cost of the contractors, and replaced by permanent structures as soon as practicable after the completion and opening of the whole road, should you, if called upon, as an engineer, to survey the road, report that the road had been substantially constructed, until they had fulfilled that part of their contract?

A.—I should think, that in order to give the contractor a claim to use trestle-work, it should be specifically stated in the contract. But then, there may be many cases where it would be policy for the owner and contractor both to agree to use trestle-work for a time, if the material for embankments was hard to be got, or they had to go a great ways to get it.

Q.—But I am assuming the case where the contractor and the corporation had made a bargain that trestle-work or temporary bridging, if used, should be changed at the cost of the contractors, and replaced by permanent structures as soon as possible after the completion of the line. In that case, should you, as an expert called upon to examine the road, report that they had completed a permanent and substantial road, until they had fulfilled that part of their contract?

A.—I should not consider it a permanent structure unless it was specified in the bargain.

Q.—I suppose you would not where it was specified in the bargain that it must be replaced?

A.—No, Sir.

Q.—[*By Hon. Mr. Greene.*] Would you consider it strange, that in constructing thirty miles of railroad, it was found advisable to construct something less than a quarter of a mile of trestle-work? Is it not better economy to fill the trestling subsequently, than to go a great distance for the material prior to laying the track?

A.—In building the Boston and Maine Railroad, we did a great deal of dressing or ballasting the road by running an engine and cars. We found that the material suitable to make the road bed had to be carried so far that it was cheaper to make it after the track was laid than before.

Q.—I will repeat my first question. Should you consider it strange that, in constructing thirty miles of railroad, it was found advisable to construct something less than a quarter of mile of trestle-work, and leave it to be filled up after the road was opened?

A.—I should not. There might be many cases in which it would be advisable.

Q.—As a general thing, do you think it cheaper to fill this trestle-work before or after the road is finished?

A.—If the material is near by, it is cheaper to fill it before. If you have to go far for the material, it may alter the decision of the question.

Q.—[*By Hon. Mr. Ritchie.*] Have you ever been on the route of this Troy and Greenfield Railroad? Do you know the character of the country?

A.—Yes, Sir. I have been in a wagon from Greenfield to the hill, and to the place where I suppose the tunnel begins on this side; and I have walked in the neighborhood of where I suppose the road is from Shelburne Falls to Greenfield.

Q.—Do you consider the route a difficult one, in regard to the grading?

A.—There seemed to me to be some difficult places. Of course, I took no notes, and made no survey. It was all by the eye. I should think the road west of Shelburne Falls was favorable, generally. It seemed to me so.

Q.—A light grade?

A.—Yes, Sir; and there cannot be heavy grades in that part of the country, I should think. Between Shelburne Falls and Greenfield, it did not seem easy to see exactly where the road would go, until you had made the surveys.

Q.—[*By Mr. Whitwell.*] Was the ballasting on the Maine road done after the regular business trains were running, or before?

A.—The dressing, with material that had to be carried six miles, as a great deal had to be, was after we opened the road for use. But there was not very much business. There were not more than four trains a day. I suspect there were but two trains for passengers, and one for merchandise, for the first month or two after the road was opened. Then there was no great inconvenience, because our sand-pits were such that we could lay an extra track along side, and calculate to be there with the gravel trains when the other trains would pass. There being only two or three of them in the course of the day, it did not interfere much with the business of the road.

Q.—[*By the Governor.*] Where the contract required that the constructor of the road should, either immediately or ultimately, fill up the trestle-work with a solid structure, and for any purpose of convenience it was found desirable to begin business on the line before the filling up was accomplished, would not there be a proportional reduction made from the contractor's compensation, to meet the expense of such filling up, unless you meant to pay the man before his work was done, or before he had undertaken to do it?

A.—We generally, when we deal with railroad contractors, do not pay them in advance. We require the work to be done before we pay them.

Q.—[*By Hon. Mr. Ritchie.*] In paying for the work, you pay as it is done; you do not wait until the whole is completed?

A.—No; the usual way is to pay on the certificates of the engineer. He certifies how much filling and how much cutting has been done, and what it comes to, at the contract price, and we pay his draft.

Q.—[*By Hon. Mr. Ames.*] Is it not customary to keep back some fifteen or twenty per cent. until the work is done?

A.—I believe it is customary to keep back something. When I was connected with the Boston and Maine road, I used to certify the amount, taking care not to go beyond what had been earned, so that it would be safe to pay the amount specified.

Q.—[*By Mr. Whitwell.*] I think you said you passed over the line between Shelburne Falls and Greenfield, or most of it?

A.—Yes, we came along the side hill by Deerfield River, until we got within a mile or two of Greenfield, and then we were uncertain where the route would go.

Q.—Would you consider it a common thing to put in trestle-work across side-hill ravines?

A.—I don't think it is common to do it.

Q.—Especially when there is material within a quarter of a mile?

A.—Well, a quarter of a mile haul is a long haul. I should give the contractor his choice, to do it either by trestles, at his own expense, or put in the material. I should require him to fill up with embankment afterwards, unless there was a bargain to the contrary.

Testimony of Mr. Charles Russell.

Question.—[*By the Governor.*] What is your occupation, Mr. Russell, and where do you reside?

Answer.—I am road-master for the Western Railroad. I live in Springfield, and have been connected with the business of railroading seventeen years.

Q.—How long have you been road-master on the Western Railroad?

A.—Four years. I have been road-master's clerk, paymaster, and assistant-superintendent.

Q.—Have you observed, either there or elsewhere, the slope used in railroad cuttings in Massachusetts?

A.—Yes, Sir, I have noticed them on the Western Railroad.

Q.—What is the slope adopted there?

A.—It was laid out one and a half to one. It is more than that in most of the cuts.

Q.—Have you any cuts with the rate of slope one to one?

A.—No, Sir; no earth cuts.

Q.—Have you observed such on any other road?

A.—No, Sir.

Q.—What cuts do you find most troublesome, clay or gravel?

A.—Clay, Sir.

Q.—In what respect?

A.—Washing down and filling up the ditches. In the spring of the year, the frost affects clay more than it does gravel.

Q.—Have you noticed the slopes in cuttings on other roads?

A.—Not particularly, Sir.

Q.—[*By Hon. Mr. Baker.*] How does it appear that one and a half to one was adopted originally by the Western Railroad?

A.—It appears by the eye that it was laid out that way, and I know by what I have heard the engineers say. If it had been laid out one to one, we should not have had the slope we have now.

Q.—Don't your slopes still continue to wash, notwithstanding they are more than one and a half to one?

A.—Yes, Sir.

Q.—You have considerable ditching to do in the spring of the year?

A.—Yes, Sir.

Q.—Under whose supervision was that road built?

A.—Major Whistler, Capt. Childs—different engineers.

Q.—What portion of the track do you have charge of?

A.—I have charge of the entire track to West Albany.

Q.—Do you give your personal attention to that, or is your business office work?

A.—I give it my personal attention. I am on the road most all the time.

Q.—[*By Hon. Mr. Ritchie.*] This matter of slopes might be determined by the engineer's estimates. All estimates have to be predicated upon a certain slope, or they could not calculate the excavations, embankments, &c.; and are these preserved—these surveys and memoranda?

A.—Yes, Sir; I know they are in the office, and I can find them, any day.

Q.—[*By the Governor.*] Is there any possible doubt what was the rate of slope adopted?

A.—Not at all.

Q.—[*By Hon. Mr. Baker.*] Does that rule apply to embankments as well as slopes?

A.—They are supposed to run that. We never slope an embankment. It is supposed that it will run one and a half to one.

Q.—I mean, so far as your observation goes, in the original construction of the embankments, is it your judgment that they were made one and a half to one?

A.—Yes, Sir.

Q.—The natural fall of the material in making embankments is supposed to come out in that way?

A.—Yes, Sir. If we were laying out a culvert, we should lay it out with a grade of one and a half to one.

The GOVERNOR. As I understand, in constructing embankments, the laws of gravitation and attraction and cohesion together make the slope.

Hon. Mr. RITCHIE. Yes, Sir; but in making up an estimate of the cost, you must make it according to the slope.

Hon. Mr. BAKER. All my observation is, that different kinds of material take a very marked difference in slope; and I supposed there was material that would require years before it would take the slope of one and a half to one.

The GOVERNOR.—[*To Witness.*] How is that?

A.—Clay might, perhaps, take more than that—flatten out to two to one.

Q.—Have you ever noticed any material that would come out one to one?

A.—I have not noticed that. Perhaps there might be some kinds of gravel that would stand that before it tumbled down.

Q.—Whether or not slopes would be more troublesome if left at the rate of one to one instead of one and a half to one?

A.—They would be more troublesome if left one to one.

Q.—[*By Mr. Stevenson.*] Did you ever have an instance of that, Mr. Russell?

A.—Yes, Sir, we have tried it in building a second track. In some instances, where we did not have time to take off the slope, we have left it straight up, and we found out the evil of it in the succeeding spring. Where we take off the slope, we don't have so much trouble.

Q.—[*By the Governor.*] How happened you to leave any such places?

A.—We left them for want of time.

Q.—[*By Hon. Mr. Ritchie.*] Did you ever leave them for the purpose of using the gravel in filling, by means of cars?

A.—No, Sir.

Q.—Supposing you wished to fill up a gorge any where with gravel, and you should leave part of the embankment until the road was constructed, would it be an economical method of filling to wait until the rails were laid, and then carry the earth from the embankment to the gorge?

A.—It depends upon whether you have the material handy to fill it in the first place. If you have, I should say it would be better to fill it when constructing the road, before the track is laid, in all cases.

Testimony of Mr. Martin B. Inches.

Question.—[*By the Governor.*] What is your profession, Mr. Inches?

Answer.—I am a civil engineer.

Q.—How long have you been in the profession?

A.—I began twenty-two years ago, on the Western Railroad.

Q.—In what capacity?

A.—I began at the foot of the engineer-corps.

Q.—Who was the chief-engineer at that time?

A.—Major Whistler was chief of the road. My particular chief was Mr., now Colonel, Barnes, of the 18th Regiment.

Q.—Do you remember what was the slope adopted on the Western Railroad?

A.—Yes, Sir; it was one and a half to one.

Q.—Have you had any thing to do with the construction and management of other railroads?

A.—Yes, Sir, I have been on other roads.

Q.—What other roads?

A.—I have been on the Worcester road and the Providence road, and I have been out of the State, in New York and New Jersey.

Q.—And what is the rate of slope, so far as you have observed or known, generally adopted in railroad cuttings?

A.—It was the same. That is the general rule everywhere.

Q.—What is the advantage of the slope of one and a half to one over the steeper slope of forty-five degrees?

A.—One to one is a steeper slope than most earths will remain at. In fact, one and a half to one is full as steep as it ought to be. Sometimes slopes are made two to one when first constructed, because one and a half to one is too steep. It is a serious matter to clean out ditches by gravel trains when the passenger trains are running.

Q.—Do you know any well-constructed railroad, or any railroad, the slopes of which are one to one?

A.—I do not know of any; though I have heard Southern engineers say that there, where they are out of the reach of frosts, in those clay countries, the slope of one to one is better. The rains are very heavy as you approach the torrid zone, and there the wash is tremendous, and the slope of one to one is better. But with us, it is better to use one and a half to one.

Q.—You have been over the Troy and Greenfield road?

A.—Yes, Sir, I went over the road with Mr. Nott.

Q.—Will you state whether you observed any thing in the character of the material over which it was built which renders that an exceptional road in respect to this rule?

A.—I did not see any exceptional place where I did not think the slopes should be flatter.

Q.—You saw no reason why the general rule of one and a half to one should not be observed there?

A.—I don't remember any instance, in any place where we stopped, where the soil would be likely to stand any thing steeper than one and a half to one. The material at Bardwell's Ferry, I think, will always give trouble, at any slope.

TESTIMONY OF MR. GORDON H. NOTT.

Question.—[*By the Governor.*] How long have you been engaged in the profession of civil engineer?

Answer.—About eighteen years.

Q.—Have you been engaged in constructing railroads during that time?

A.—Part of the time; and all the time connected with railroads.

Q.—With what roads have you been most familiar?

A.—The Gloucester Branch, the Eastern road, the Manchester and Lawrence road, in New Hampshire, the Boston and Worcester, Boston and Providence, and the New York Central.

Q.—Did you pass over the Troy and Greenfield road, from Greenfield to the Hoosac Mountain, last week, and come back over it?

A.—Yes, Sir.

Q.—What is the rate of slope adopted for cuttings on the roads you have been connected with?

A.—One and a half to one.

Q.—Will you state whether you observed any thing in the nature of the material of the Troy and Greenfield road which would give good reason for changing the usual rate of slope there?

A.—I should think not—no, Sir.

Q.—Is there any thing characteristically different about the material of that road over other roads where the rate of one and a half to one has been adopted?

A.—I should think not.

Q.—From your observation and experience on railroads, should you call that road substantially constructed, the slopes being left at the rate of one to one?

A.—No, Sir, I should not.

Q.—Is there any thing else which you noticed in regard to that road which requires special mention?

A.—I took some pains to notice the natural slopes, and I think I saw practically nothing that would give less than two to one, unless it was ledge, or composed mainly of ledge, cropping out, perhaps, at some points.

Q.—[*By Hon. Mr. Ritchie.*] You mean the natural slope of the hill was two to one?

A.—Yes, Sir.

Q.—[*By the Governor.*] Do you consider trestle-work to be a substantial construction?

A.—No, Sir, I do not.

Q.—[*By Hon. Mr. Ritchie.*] There's a pretty steep hill near the gorge below Bardwell's Ferry. Is not that more than two to one? If you should slope one and a half to one there, you would have to run to the top of the mountain, would you not?

A.—I should think not.

Q.—[*By Mr. Whitwell.*] You think you saw no places there which were steeper than two to one?

A.—I think I observed nothing steeper, unless it was ledge.

TESTIMONY OF MR. SAMUEL ASHBURNER.

Question.—[*By the Governor.*] How long have you been a civil engineer?

Answer.—I have had no other occupation since 1833.

Q.—With what railroads have you been familiar, as engineer or manager, or otherwise?

A.—I was first on the survey of the New York and Erie road, then I was on the Worcester road, then on the Eastern road, then on the Portland, Saco and Portsmouth road, of which, jointly with Mr. Nott and Mr. Hall, I acted as principal engineer. Since then, I have constructed, as chief-engineer, part of the Cocheco road, the Rochester Branch, the Salisbury Branch, and seventy odd miles of the Providence, Hartford and Fishkill road. That is the last work I have been on.

Q.—What is the rate of slope adopted in cuttings on those roads, or is there no uniformity?

A.—It is almost invariably one and a half to one. I might save time by stating (if I may be permitted) that I should corroborate, almost wholly, the testimony which I have heard these gentlemen give, so far as my experience goes. I have been over only four miles of the Troy and Greenfield road, at the Greenfield end; but, generally speaking, I should corroborate their statements fully.

Q.—Is there any thing in the character of the material there that would have a tendency to vary the general rule for slopes?

A.—Nothing that I saw. I think the rule may be called invariable. It is so universal, that there is no other expression so well suited to it. That is to say, the practice in New England and elsewhere.

Q.—You concur in the opinion expressed by these other gentlemen, that trestle-work is not to be considered a substantial construction?

A.—I do, Sir.

Q.—[*By Hon. Mr. Greene.*] Were you engineer of the Cocheco Railroad?

A.—I was, Sir. I was engineer of twenty-one or twenty-two miles. After I left the road, it was carried ten or twelve miles further.

Q.—What was the amount of trestle-work on that road?

A.—There were two places. One was the Blackwater bridge, four or five hundred feet; the other was a piece of much more permanent work, near Rochester.

Q.—Was that trestle-work filled up before the road was operated?

A.—No, Sir; it is not filled up to this day.

Q.—How long a time is it since it was put in?

A.—I should think some thirteen years.

Q.—That is a branch of the Boston and Maine road?

A.—It is, practically.

Q.—Is there much business carried on over that road?

A.—I cannot say. I should state (what Mr. Hayward did not state) that trestle-work is used for two purposes, and quite as much for one as for the other. It is used as a water-way, in order to allow water to spread over a great extent of land. That was the purpose of the trestle-work on the Cocheco road. It was considered cheaper to bridge it in that way than any other. So that it does not come into this category at all. I cannot tell how much of the old trestle-work is standing now; but I can give you testimony in regard to a much longer piece on the Hartford road, over the Connecticut River, which was over a mile long. It was constructed as well as ordinary trestle-work. When I went there, it had been built not over five or six years; and the first thing I was called upon to do was to make that trestle-work tolerably safe for the trains. I was on the road for five or six years, and it was a constant source of inconvenience, the trains creeping over it at the rate of eight miles an hour. I have no doubt that when it was built, it was expected to last much longer than it did.

Q.—[*By Hon. Mr. Baker.*] In regard to the Gloucester Branch road, was there not a large amount of trestle-work built upon that?

A.—Yes, Sir; which I understand has since been filled up.

Hon. Mr. BAKER.—That stood some thirteen or fourteen years before it was filled up?

WITNESS.—The same explanation should be made in regard to that that was made in regard to the trestle-work on the Cocheco road, for they were, to some extent, parallel cases. The trestle-work on the Gloucester road was where some kind of water-way was required. The material for filling at their hand was very hard, and it was extremely difficult to get. Still, this could hardly be called a first-class structure. That is to say, the Gloucester Branch was not a first-class road.

Q.—There has been a large amount of business transacted on it, has there not?

A.—Yes, Sir, I suppose there has.

Q.—Now, as to the practical fact, what road have you ever known to which this rule has been practically applied, which has not been accepted from the contractors until the slopes, in earth work, were made one and a half to one?

A.—Every road I have ever known. The Eastern road, all the roads that I mentioned, and all the roads that I am familiar with.

Q.—You are confident that before the Eastern road was accepted, the slopes were one and a half to one?

A.—With the explanation that I make, almost universally. There were exceptions, undoubtedly; but the road, as a road, was to be finished in that way.

Q.—Will you name a single one of the cuts that was reduced to that slope before the road was accepted?

A.—I will, Sir. The cut at Castle Hill, which you cited as an instance to the contrary, I happened to be in the immediate charge of, and I recollect particularly that that was finished as nicely as it could be at one and a half to one before it was accepted. There is a cut through Lynn, with which I was not immediately connected, but in regard to which I can testify with equal certainty.

Q.—That is not so deep a cut as the one at Castle Hill or at Beverly?

A.—No, Sir, I should think not.

Q.—That is the only cut you remember upon that road that was actually finished with that slope?

A.—No, Sir. If it was not for occupying your time, I could go over all the cuts in detail.

Q.—How was it with the East Boston cut?

A.—That is an exception. I was not employed upon that. But I think it is perfectly fair to say that, speaking generally, that was the rule on the Eastern road, and that where cuts were left unfinished, they were exceptions for reasons that have no bearing upon the general question.

Q.—[*By Hon. Mr. Hayden.*] If you were to build a good and substantial road, would you lay down the track, in any case, and reduce the slopes after the track was down, and fill up the ravines where it was necessary, or do it all before the track was down?

A.—I should, if possible, do it all before the track was down.

Q.—You think there would be no saving in laying the track, and reducing the slopes and filling up the ravines afterwards?

A.—I can understand that some cases might occur where a saving would result from that course; but I think it would be a very extreme case that would allow any thing of that sort. My practice has always been to avoid any thing of that kind, and make the road thorough and permanent before the superstructure is laid down.

Q.—Then you do not think the slopes could be reduced at less cost after the rails were down than before?

A.—I think it would cost more, Sir.

Q.—[*By Hon. Mr. Baker.*] How wide do you calculate the base of a road for a single track?

A.—The most common width has been twenty feet.

Q.—How much would you add for a second track?

A.—It should be from twenty-six, as the minimum, to thirty feet. Thirty feet is much better than twenty-six.

TESTIMONY OF MR. THOMAS S. WILLIAMS.

Question.—[*By the Governor.*] You have been connected with the Boston and Maine Railroad?

Answer.—Yes, I was superintendent there for five or six years.

Q.—Are you familiar with any other road besides the Boston and Maine?

A.—Yes, Sir; I was one of the engineers of the Lowell Railroad, from its commencement to its completion; also of the Worcester road, and of the Boston Water Works.

Q.—What is your opinion, based on your knowledge and experience, of the appropriate slope for railroad cuttings in Massachusetts?

A.—It would be the same that has been expressed here generally. On the Lowell Railroad, which I was familiar with throughout, the slope was made one and a half to one. The slopes on the Worcester road, of which I had charge of twenty miles, were the same. Our calculations were always based on slopes of one and a half to one. It is the almost universal standard.

Q.—Have you ever seen the Troy and Greenfield road?

A.—I have not.

Q.—Assuming a single track railroad, over a great line of travel, like that anticipated for the Troy and Greenfield road, do you think that the slopes can be reduced after the road has gone into operation at less expense than before?

A.—That would depend upon circumstances. It might, where the haul was very long, be done at less expense with a locomotive and cars; where it was very short, it might be done with teams.

Q.—Is it not an inconvenience to your passenger and freight trains to attempt to do it after the road is in operation?

A.—It is not as convenient, but it is always done, more or less.

Q.—I speak of a case where you have got your whole line to reduce from one to one and a half?

A.—I should still say, that for short hauls, I should use teams; on long hauls, I should submit to the inconvenience of using cars and engines.

Q.—Did you ever know a road to be left in that way, with the cuttings at the rate of one to one, to be reduced after the road was opened to travel?

A.—To some extent. I was on the Sullivan road, and that was left, in part, in that way. The slopes were taken off hastily, and after I went on to the road, I completed it by having the slopes reduced by the use of locomotives and cars. The slopes there were finally left at one and a half. That was the intention.

Q.—[*By Hon. Mr. Sleeper.*] That did not interfere with any contract?

A.—I think that was done after the contractors left the road. The contractors generally failed, as has frequently been the case on our railroads. Very many of them have failed, and the roads have had to be completed by the companies.

Q.—Should you consider a road substantially constructed until the slopes had been reduced as much as one and a half to one?

A.—I should not, ordinarily. Most all earth requires as much slope as that.

Q.—[*By Mr. Stevenson.*] Is it not customary, or oftentimes found convenient, to lay the track at sub-grade, and so facilitate the taking out of the slopes by an engine and cars?

A.—It is very often done.

Q.—I think that in the construction of the Lowell road, they deemed it necessary to lay the rails in stone, and they also laid down stone ties?

A.—Yes.

Q.—Would you adopt that course if you were to construct a road now?

A.—No, Sir.

Q.—And if you found, by working certain kinds of earth, that that earth would stand at a slope of one to one, would you consider it necessary to reduce the slopes to one and a half to one afterwards?

A.—If I found it would stand so permanently, I should not.

Q.—Would it not be as well to leave such slopes as were found to stand tolerably well at one to one to be taken off afterwards by a train?

A.—As far as my observation goes, slopes in earth always will reduce themselves as flat as one and a half to one.

Q.—Where there was a surplusage of material, would it not be advisable to leave them until they could be taken out by a gravel train?

A.—It would be a matter of calculation of dollars and cents.

Q.—Would it be safe, in your opinion, to leave the slopes one to one, if the width of the road-bed was so increased that, if the slopes were to assume such an angle as is represented by one and a half to one, it would not be unsafe to leave them in that way?

A.—I don't see any danger that would arise, unless there were stones that might fall down.

TESTIMONY OF MR. SAMUEL NOTT, *recalled.*

Question.—[*By the Governor.*] Did you have your attention called to the question whether any thing was necessary to be done for the protection of the embankments during the winter and spring?

Answer.—Yes, that was spoken of, and I noticed the position of the road as to that point.

Q.—What needs to be done, and where, and at what probable expense?

A.—There was evidently a good deal to be done at various points to secure the embankments from freshets on the river. The rise appeared to be six or eight feet, as near as I could tell by what I could see most of the way; and for a good part of the way, there was a good deal of exposure to wash from the river; but as to how much the whole length of road was exposed I cannot state, nor what it would cost to protect it. I did not follow the whole thing along systematically enough to be able to give an approximation, even, of the probable expense; only I should say, generally, that between Bardwell's Ferry and the Tunnel, there must be several miles of the road that would need some protection.

Q.—What description of work is needful for that protection?

A.—Generally, the case would be met by loose rock thrown off at the side—rip-rapping.

Q.—Would that be a sufficient protection?

A.—I don't think I saw any place where that would not prevent the trouble.

Q.—How great a distance do you suppose there is of the road thus exposed ?

A.—I tried at one time to follow the thing along so as to come to a pretty close idea about it, but found I could not do it very well. I don't know, but I have a rough idea that on one side, for three or four miles, there might be something of that sort to be done.

Q.—[*By Hon. Mr. Baker.*] If that is not done, one winter would be likely to make pretty serious havoc with such a road as that, would it not ?

A.—Yes, Sir; at some points, there might be mischief done, in the early life of the slopes.

Adjourned until Wednesday, at 11 o'clock.

SECOND DAY.

WEDNESDAY, September 25.

The hearing was resumed shortly after 11 o'clock.

TESTIMONY OF MR. ALEXANDER HOLMES.

Question.—[*By the Governor.*] How long have you been connected with railroads ?

Answer.—About ten years.

Q.—How long president of a railroad corporation ?

A.—Seven years.

Q.—What is the slope of the cuttings on your road ?

A.—I am not an engineer, but my best judgment is that our cuts are from one to one to one and a half to one—so made at the commencement of the road, and they have been gradually running down. There are many banks that are now standing, I should judge, about one to one; but a road, to be thoroughly and substantially built, should have its slopes one and a half to one. I have no doubt about that. But they are not all built so. The roads in New England have not been built in a substantial manner, in my judgment; but in the haste to open them, as little dirt as possible has been taken out from the cuts, some trestle-work, and other temporary work, built for the time being, with the calculation to make it more permanent afterwards—which has been bad policy, in my judgment.

Q.—[*By Hon. Mr. Greene.*] I would like to ask you whether, from your experience, you would consider it advisable, in finishing a road, to fill up the trestle-work before the road was opened, if by so doing you delayed the opening, and consequently lost whatever of income there was to be derived from the traffic ?

A.—It would depend entirely upon circumstances—what the income would be. It would cost more to fill the trestle-work after the road was opened than before.

Q.—Would it, considering the fact, I mean, that the income would be postponed?

A.—The income to be obtained would offset, to some extent, the increased expense. It is much more expensive to run a gravel train after a road is opened than before. You have then large gangs of men employed, and they are detained, and the risk is increased. Still, you must have a gravel train, under any circumstances. At least, we have always had to have one.

Q.—Would not the loss from the delay in opening the road counterbalance the extra expense of running the gravel train?

A.—I should judge it would.

Q.—[*By Hon. Mr. Ames.*] You say you have some embankments that stand one to one?

A.—I think we have.

Q.—[*By the Governor.*] Slopes or embankments?

A.—The slopes in the cuttings. Some kinds of material will stand much more upright than others. We think a stony, coarse gravel is altogether better than sand, clay or loam for railroads; that is, it will stand at a sharper angle. I should not consider an embankment where there were large stones safe at an angle of one to one, for the reason that the stones might become detached by the frosts, and be thrown upon the track and interfere with the trains.

TESTIMONY OF GEN. GEORGE STARK.

Question.—[*By the Governor.*] Gen. Stark, where do you reside?

Answer.—I reside at Nashua.

Q.—You are a civil engineer by profession?

A.—Yes, Sir.

Q.—And how long have you pursued that profession?

A.—Some twenty years.

Q.—In New England?

A.—Yes, Sir, mostly.

Q.—What is the usual and approved slope for railroad cuttings, in New England?

A.—The customary slope in New England has been one and a half to one, for earth cuttings—one and a half horizontal to one vertical.

Q.—What is, in your opinion, the safest and best slope to adopt, that, or any other?

A.—I should adopt that in preference to any other, in the general quality of earth.

Q.—Have you ever constructed any roads yourself, as engineer?

A.—I have. I constructed the road from Lowell to Groton Junction, the road from Nashua to Wilton, and a portion of the road from Concord (N. H.) to the Connecticut River, on the Boston, Concord and Montreal road, through Meredith and Plymouth.

Q.—Did you adopt the slope of one and a half to one on all those roads?

A.—I did. I have also been in the engineer department of quite a number of other roads, as assistant-engineer, where the same slope was adopted—the Old Colony, among others. That was originally laid out one and a half to one, and the first track was so constructed. I was upon the road, in the engineer department, during its construction.

Q.—When you adopt a particular rate of slope, do you or not, in your capacity of engineer, undertake to see that it is faithfully carried out by the contractors?

A.—That has been the custom I have always insisted upon when I have had charge of work, and I was always required to insist upon it by engineers over me, where I was on as assistant.

Q.—Is it your opinion that a road can be considered substantially constructed which has adopted the slope of one to one?

A.—I should not consider it substantially made.

Q.—What is your judgment of the good workmanship of leaving trestle-work in ravines unfilled? Do you call that a substantial making of the road?

A.—No, Sir, I should not call it completed. Trestle-work might be left unfilled as a matter of contract.

Q.—Take just such a case as this, Sir. Suppose a contractor to have made a contract with a corporation which requires him ultimately, if not at once, to fill up the trestle-work with solid embankment, and you were called upon as an engineer to report whether the road was substantially constructed, should you report it to be substantially built before that part of the contract was executed?

A.—I should not consider the trestle-work a proper completion of the road, under that agreement.

Q.—[*By Hon. Mr. Greene.*] If the natural slope of the material was one to one, should you then prescribe one and a half to one for the cuts?

A.—No, Sir; but I never saw a natural slope of one to one.

Q.—Would you consider it good policy to go beyond the natural slope, as a general thing?

A.—There would be no occasion for that, Sir. There might be a question, perhaps, as to what was the natural slope.

Q.—[*By Hon. Mr. Baker.*] Gen. Stark, can you apply the one and a half rule to all sorts of material, whether it be sand, gravel, or hard pan?

A.—I have never seen any material that would not ultimately come down to one and a half to one, except rock or blasted stone, or something of that description. There are some hard pans that will stand very nearly perpendicular for a time, but, with very few exceptions, they wash down after a few years.

Q.—Are there not some portions of the Montreal road where there is hard pan standing one to one?

A.—I have no doubt that there are some places where it stands more than one to one; but they are exceptions.

Q.—When you come to put in a double track, are there not many places where you do not alter the slope at all, but allow it to come down with a more abrupt descent than one and a half to one?

A.—My experience is that all material will come down to one and a half to one. When it arrives at that slope, it is generally safe.

Q.—Is it or not your observation, that where the slope may be one and a half to one with a single track, when they come to lay a second track, they take out a part of the slope, and let it stand?

A.—I have seen cases where the slope has been taken out one-half, substantially making it one and a half to one.

Q.—I don't understand how that should make the slope one and a half to one.

A.—I mean this: instead of sloping the bank, the cut was made one-half the width of the slope wider, and left to stand perpendicular, if it would stand so; so that when it sloped itself, it would run out and make a slope of one and a half to one, in time. That is, you would cut out as much at the bottom as if you sloped it, and then one-half the slope horizontally.

Testimony of William B. Brinsmade.

Question.—[*By the Governor.*] Where do you live, and what is your profession?

Answer.—I live in Springfield. I am superintendent of the Connecticut River Railroad from Springfield to the Vermont line.

Q.—You are a civil engineer by profession?

A.—I am, Sir.

Q.—How long have you pursued that profession?

A.—Since 1841, until about four years ago. Since then, I have been connected with the road as superintendent.

Q.—Have you ever been engaged as an engineer in the construction of railroads?

A.—Yes, Sir, altogether, from the time I commenced until about the year 1856.

Q.—With what roads?

A.—On several roads in Massachusetts and Connecticut, and in New York, Pennsylvania, and Ohio. I have been connected with the New York and New Haven, Vermont and Massachusetts, Connecticut River, Troy and Rutland, and two or three roads in Ohio.

Q.—What is the slope for railway cuttings which you have adopted or found usually adopted by engineers?

A.—The usual slope of earth on all roads is one and a half to one. Sometimes it is required to be more; sometimes a less slope is required. That is the usual slope.

Q.—When you depart from that usual slope of one and a half to one, for what reasons do you do it?

A.—On clay and quicksand, we very often take out the slope two to one. We judge, of course, by experience, what will be necessary in the construction of a road. If it is rock cutting, it may be sometimes a perpendicular slope, or perhaps three inches to a foot. If it is rock and hard pan, sometimes six inches to a foot. The slope is varied according to circumstances, in the exercise of the judgment of the engineer. One and a half to one is the rate upon which the estimates for the road are based.

Q.—A departure from that is always regarded as simply exceptional?

A.—Yes, Sir. Sometimes the slope is varied. Engineers differ in regard to what is best in the construction of a road—whether to finish it entirely with the regular base of twenty feet, and make the slope one and a half to one, or make the base wider, and then slope one to one, taking out the same amount of excavation. That is, in order to save the earth coming down into the ditches, they make a steeper slope, and in that way, they have the same base away from the track. I have seen blue clay taken out from some excavations, and left, twenty feet from the rails, to slope itself. Then, whatever material is to be taken out can be removed easily; care being taken to take out the same amount of excavation and leave a wide space. Sometimes it will stand nearly perpendicular for some time. But engineers generally prefer to take it out one and a half to one. On our road, the clay is so mixed that when it is wet, it comes down, and stands now, measuring from the track, about two to one.

Q.—Do you consider that a road is substantially constructed if the trestle-work over ravines is left unfilled with embankments?

A.—It is sometimes necessary, where they cannot get material, to build trestle-work.

Q.—But suppose the material is within reach, reasonably?

A.—I should prefer solid embankment.

Q.—What is the custom?

A.—The custom varies. Usually embankments are made solid, with culverts; but sometimes, if they are in a hurry to complete the road, and material is not convenient, the ravines are crossed with trestle-work, and filled in afterwards. A great many roads in the West are built in that way.

Q.—Take New England for the standard, and not the West?

A.—The embankments, as a general thing, are made at the time the roads are built.

Q.—Supposing a contract to be made, and nothing said about trestle-work in it, should you accept a road as complete with trestle-work and without embankments?

A.—That would depend upon what sort of a road I wanted to build.

Q.—Supposing the road was to be substantially built—without ornament, but substantially built?

A.—I should not accept it as completed until the trestle-work was filled in with earth.

Q.—Have you ever seen the bridge on the Troy and Greenfield road, where it crosses the Green River?

A.—I have seen it, as our trains pass in view of the bridge; I never have examined it particularly; never have been upon it.

Q.—Have you ever examined it so far as to be able to express any opinion upon it?

A.—Nothing more than a general opinion. I have seen occasionally diagrams of it, and I have seen it frequently, as I was passing the bridge every day.

Q.—You would not be able to give any critical opinion about it?

A.—Only a general opinion; the same as a man who has the plans shown him might, at a casual glance, give an opinion in respect to two bridges.

Q.—[*By Hon. Mr. Greene.*] Are you acquainted with the Canal road from Northampton to Hartford?

A.—I have been over portions of it many times, but I have been over the whole of it but once.

Q.—Do you know any thing of the slopes on the last thirty miles of that road ?

A.—I should judge they must be one and a half to one, knowing what the material is.

Hon. Mr. Greene.—I was told by the superintendent they were only one to one.

Witness.—I should judge a great deal of the material was loam, gravel and sand, and I know it would not stand long without a slope of one and a half to one.

Q.—Are you acquainted with the material on the Troy and Greenfield Railroad, from the Tunnel to Greenfield ?

A.—No, Sir, I have never been over any part of the road. I went over the western end a number of years ago, but not since it was called the Troy and Greenfield road.

Q.—If you had two opinions before you in regard to a bridge, one formed by an engineer after an observation of half an hour, without the particulars of the size of the rods, &c., and the other based on calculations made by an experienced engineer, according to the rules laid down in the science of engineering for calculating the strength of bridges, upon which should you place the most reliance ?

A.—I should rather know the persons.

Q.—Taking two engineers of equal merit ?

A.—I should not want to rely upon any calculations, unless I made them myself.

Q.—Well, Sir, would you rely upon the casual observation of a man looking over a bridge of that description for half an hour ?

A.—If he was a man of experience, who knew what was required, his judgment, from an observation of half an hour, might be worth more than another man's, who had made all the calculations in the world, if he had no practical experience.

Q.—Supposing he was a scientific man, who had built a great many bridges and been in the habit of making such calculations for many years, and was a man of entire integrity, then would you put the greatest reliance upon his calculations, or upon the observation of an engineer of equal standing, who had entered into no calculations ?

A.—Of course I should put the greatest reliance, other things being equal, on the man who had given the longest attention to it.

Q.—Would you not rely more upon your calculations about a bridge than a casual observation ?

A.—I would rather trust a plan of bridge about which there would be no doubt, if I was building a bridge to trust human life to. As you state the question, of two men having had equal experience, I should suppose the man who had had the most opportunity to examine the bridge would be the most reliable.

Q.—Is there unanimity of opinion among engineers in relation to which is the best bridge ?

A.—No, Sir. Some prefer one and some another.

Q.—[*By the Governor.*] Supposing that you, as an engineer, acting in your profession, had laid upon you the responsibility of reporting upon the character and permanence of a bridge which was new as an invention, and had broken through once, under the weight of a burden, should you not feel great hesitation, on any body's calculations, in pronouncing it substantially perfect, until it had been tested by actual experiment, before trusting human lives to its strength?

A.—I don't think much of any test you can apply to a bridge, and never have. Of course, if a bridge has fallen, before adopting it, or passing an opinion upon it that it was safe, I should think it necessary and important to pay more attention to it than if it had not fallen, to see if there was any thing defective in the bridge. Sometimes, a plan may be right, and there may be some defect in the construction—it may not be thoroughly built. The best plan in the world may fail. I have known several of the Howe bridges to fail, (and perhaps there are more bridges of that style built throughout the country than any other,) entirely through unskilful mechanics.

Q.—[*By Hon. Mr. Greene.*] Supposing that you should find that the fall of the bridge was occasioned by the carelessness of a blacksmith in putting a hoop round a cylinder hot, as a tire is put on a wheel, the shrinkage of which caused the cylinder to crack, and the bridge fell in consequence of that construction of that particular cylinder,—would that fact give you a general impression against the bridge, provided the cylinders were made substantially strong?

A.—If I was satisfied that that was the fact, and every thing was made all right, of course that would explain it.

Q.—[*By Hon. Mr. Hayden.*] You say you have known several instances where the Howe bridge has failed. What was done after the failure?

A.—I have never known but one fail on the first trial. I have known one case somewhat similar to this bridge at Greenfield. That was on the Vermont and Massachusetts road. But in that case, it was shown that there had been a strike among the laborers, and there was good evidence that a number of the nuts had been stricken from the bolts.

Q.—The principle was not condemned in consequence of that?

A.—No, Sir.

Q.—[*By the Governor.*] That was a case where the bridge had been tampered with.

A.—Yes, Sir; of course the strength of the bridge was gone, a number of the nuts having been removed.

Q.—Suppose you assume that a principle is a sound one, if you find it to have failed in some details, by reason of a defect in the manner of carrying them out, does not that raise some apprehension that the other details may have been imperfectly carried out?

A.—Yes, Sir; especially if the bridge is a new one. In that case, of course it is necessary to examine other points. As soon as the bridge on the Vermont and Massachusetts road failed, engineers and bridge-builders were very much interested in the question as to what was the cause of its failure, and they were not easy until it was fully settled that it had been tampered with.

TESTIMONY OF MR. LEWIS BROAD.

Question.—[*By the Governor.*] Where is your home, Sir?

Answer.—Boston, Sir.

Q.—What is your occupation?

A.—I am a railroad contractor.

Q.—How long have you pursued it?

A.—Twenty years.

Q.—On what roads?

A.—Several roads in New England, and largely in the West. I was engaged on the Providence and Worcester, the Boston and Worcester, the Norwich, and other connecting roads, the Cheshire road, and more largely in the West.

Q.—What is the rate of slope adopted in railroad cuttings in Massachusetts?

A.—One and a half to one, where it is earth material.

Q.—Is that the rate of slope which has been adopted on the roads on which you have worked?

A.—Yes, Sir, I believe so. I don't know of a road in New England where that has not been the slope adopted. I mean, generally. There may be exceptions on the same road. There may be some cuts where the slope would be greater.

Q.—[*By Hon. Mr. Baker.*] What is the greatest slope that you were ever called upon to make, as a contractor?

A.—Two to one has been what is called the flattest slope.

Q.—Did you ever make a two to one slope under contract?

A.—I don't recollect that I ever did.

Q.—Have you ever made any over one and a half to one under contract, in any kind of material?

A.—I don't think I have; and very seldom less than one and a half to one. In the Western country, we have very seldom adopted less than one and a half to one. In some cases, as has been described here by gentlemen, clay cuts are taken out wide, and left to slope themselves.

Q.—Are you acquainted with the material on the line of the Troy and Greenfield Railroad?

A.—I am not acquainted with it at all.

Q.—[*By Hon. Mr. Shute.*] What is the usual width of road-bed on railroads?

A.—Not less than eighteen feet in New England; generally, twenty feet. In the West, twenty feet, very uniformly.

Q.—How narrow is the narrowest?

A.—I don't know that I am able to say. On many roads, I have cut through as soon as possible, in order to hasten the opening of the road, and afterwards taken out the material by trains. But I don't think of any finished road that is less than twenty feet.

Q.—How wide is the widest bed?

A.—I think the widest I ever saw was twenty-one feet, for one track.

Q.—[*By Hon. Mr. Ames.*] In the cuts or on embankments?

A.—In cuts. Embankments are usually less—from fifteen to eighteen feet. I have known embankments to be only fourteen feet. The road-bed on the

Illinois Central road is twenty feet, uniformly, in earth cuttings; in rock cuttings, less.

TESTIMONY OF MR. C. L. STEVENSON.

Question.—[*By Hon. Mr. Greene.*] Do you agree with the testimony given here in relation to the usual slope being one and a half to one on the railroads in New England?

Answer.—I do, Sir; I have always been in the habit of using that slope.

Q.—Will you state to the Council, if you know, the reason why Col. Lincoln adopted, and you subsequently adhered to, the slope of one to one, on the Troy and Greenfield Railroad?

A.—It was based upon a very careful survey of the road, and the peculiar features of the country. It is usually my custom to *estimate* on a slope of one and a half to one; but as this was a case where the monthly payments were based upon the amount that the whole road was to cost, it was necessary that we should make a very thorough examination. The result was, that we found that the road was mostly located along a very steep side hill, and that there was a surplusage of material in all the cuts, even with a slope of one to one. As the places where material was wanted were a long distance off, it would have been a sheer waste of material and money to have taken the banks down one and a half to one, inasmuch as there were deep ravines which it was necessary to fill, and it was important to reserve as much material from the side cuttings to fill up those ravines as we could. We found, from the careful examination then made, and the soundings taken, that the earth was of a peculiarly tenacious character, that would stand at a slope of one to one with less wash than most any material I ever saw. I except, of course, the sand and gravel cuts near Greenfield. Between Stillwater Point and Shelburne Falls, there was not suitable material enough to ballast up the six miles of road. It was therefore necessary that the ballasting material should be taken from the cuts near Greenfield, between Stillwater and Shelburne Falls. If we had reduced the slopes one and a half to one, of course we should simply have taken out material that was wanted for other parts of the road. It would then have been necessary to go into some borrow-pit to obtain earth to fill ravines, &c. It was, therefore, good economy to leave the slopes at an angle of forty-five degrees, to be taken out afterwards. Wherever we had any doubt as to the slopes left one to one standing, it will be noticed that a greater width has been given to the road-bed, to admit of the earth's sliding. It was intended, after the road was running, or rather, after a track had been laid at sub-grade, to take out any surplus material that might come down from these cuts, and use it to fill up the ravines, so that the slopes which were, at the outset, one to one, would eventually assume such slope as the material would take. It has been generally the custom here to stake out roads one and a half to one. This is the first instance that I ever had of a slope of one to one throughout an entire line of road. It is the custom in Ohio and Pennsylvania to stake out roads with that slope, for the same reasons that operated here. It is only at special places that surplus material can be obtained, and it is therefore the custom to leave it until a train can go on the road and remove it to where it is needed. It certainly would seem to have been poor economy to remove earth, when we should have had to borrow material to ballast the road and fill ravines at an increased expense.

Another reason was, that all the available means of the contractors were required for expenses outside of those provided for by the amount loaned by the State. That only pays for the graduation, masonry, bridging and superstructure; every thing else is done by the contractors. At the outset, they showed us that all their available means must be devoted to sinking the shaft and excavations at the west end of the Tunnel, the construction of county roads, (for which the State made no payments,) and many other things, in order to complete the road as fast as possible. It therefore devolved upon us to decide what sort of a road should be made. We decided that the road should be finished in the manner in which roads usually are, when opened for business. The result of the testimony yesterday, I believe, was to show that where trestle-work has been used, the roads have been opened with it, and it has been filled up afterwards. There is less than a quarter of a mile of trestle-work on the whole line of the Troy and Greenfield road.

Hon. Mr. Greene.—You have heard the testimony here, and any statement that you may wish to make upon the matter in controversy, or as explanatory of your policy as State Engineer, I suppose will be in order.

Witness.—There does not appear to be any matter in controversy, for I think I should agree, in the general principles advanced, with all the engineers heard here yesterday. I think, if they had had the opportunity of judging of this road that Col. Lincoln had, at the time he established the policy to be pursued, they would have decided in the same way. It was a peculiar case; one which required the greatest care, and one which every body knew would be likely to be subjected to just such an examination as we have had here. The preliminary investigations were therefore made with great care, and precaution taken to guard the interests of the State in every shape and form. It was believed by Col. Lincoln that the interests of the State would be better promoted by opening a road as quickly as possible to the Tunnel, which was substantially built, in the ordinary acceptation of that term, and that no expense would accrue to the State from filling up the trestle-work, inasmuch as, from the necessity of clearing out the slides, it would be filled up at an almost imperceptible expense by the Troy and Greenfield Railroad Company. The State would have had a completed road, and some tangible security for its loan, at this time, if the work had not been stopped. I think it would have required only some six or eight weeks to have completed the road from Greenfield to Shelburne Falls.

Q.—[*By Hon. Mr. Greene.*] In relation to the bridge, will you state your opinion, and what means you have of forming an opinion?

A.—The bridge was designed by Mr. Haupt himself, and the designs were submitted to Col. Lincoln, who gave them, I think, more examination at that time than I did. Subsequently, however, when the materials were delivered on the ground, I made some measurements of the principal rods, timbers, &c., and, with the assistance of the plan, made my calculations upon them. I found that, theoretically, it presented a greater amount of resistance to the weight likely to be brought upon it than is usual with the Howe and Pratt bridges. I paid no more attention to it until after the fall of the span. I then gave it considerable attention, and arrived at the same conclusion as the other engineers in regard to the cause—a defect in the details; one which I think is fully obviated by the change in the cylinders.

Q.—Did you make any calculation of the weight the bridge would bear?

A.—I did.

Q.—What was that, in comparison with the greatest weight that would be put upon it?

A.—The bridge would sustain six to eight times the weight that would come upon it. Estimating the breaking weight at 60,000 pounds the square inch, the greatest weight that could be brought to bear upon it was from six to eight thousand pounds the square inch.

Q.—Is this business of calculating the strength of bridges recognized as a science, and taught in the schools?

A.—Yes, Sir, it is.

Q.—To what distance would it be necessary to bring the material to fill up the longest piece of trestle-work?

A.—The nearest material that can be obtained readily—that is, without its being hard earth or rock—is from a quarter to half a mile distant. But at a little distance beyond that, clear gravel can be obtained, at a very small expense.

Q.—Considering the distance at which the material is to be had, would it, in your opinion, be more economical to fill that trestle-work before or after the opening of the road, taking into consideration the delay in opening the road?

A.—I think the best answer to that is in the fact that I confirmed the policy of building the trestle-work for this very reason—that it would be more economical to fill it from gravel pits, by trains, than to haul the material the distance I mentioned.

Q.—How long should you suppose that trestle-work would last?

A.—I am not familiar with the life of trestle-work, but contrasting it with trestle-work not nearly so strong, which has stood eight or ten years, I should certainly set the life of this at twelve years.

Q.—Would there be any difficulty in substituting new parts for such parts as might show signs of weakness?

A.—No, Sir; there would be very little difficulty.

Q.—From your experience and observation, would you or would you not consider a road finished on the basis adopted by your predecessor and yourself as a safe road for the transportation of freight and passengers?

A.—It could hardly be considered a finished road; it would be a perfectly safe road, and finished as roads ordinarily are here, when opened for the transportation of passengers and freight.

Q.—What is the general character of the material used for bridging, &c.?

A.—It is very good. The stone work is as good as the stone of the country would admit. A portion of the stone work has to be left until stone can be brought down in cars, there being no other means of obtaining it.

Q.—Would any slighting of the work, or any failure to bring it up to the proper standard, fall upon the sub-contractors or the principal contractors?

A.—It would fall upon the sub-contractors.

Q.—[*Exhibiting a paper.*] Do you know whether that is the form of contract adopted?

A.—That is the usual form. I would state, that the same quantities found by the State Engineer are used in making the payments to the sub-contractors.

Q.—[*By the Governor.*] If in a contract with the corporation, the contractors should agree to replace trestle-work by embankment, should you be willing to accept the work until that was done, if you were called upon to decide whether the work was substantially completed and built?

A.—Most assuredly not, on the supposition that the contract specified that the trestle-work should be filled up. The basis of operations on the Troy and Greenfield road does not admit of such a supposition, because trestle-work was admitted by Col. Lincoln as necessary.

Q.—[*By Hon. Mr. Greene.*] Was that in the nature of an understanding or contract between Col. Lincoln and Mr. Haupt?

A.—It was in the nature of an understanding, not of a written contract. It was understood before any portion of the road was made, beyond the first three or four miles.

Q—[*By the Governor.*] Where is that understanding made apparent?

A.—It is not made apparent, except in the preliminary estimates.

Q.—Where are they?

A.—I have the original, and also copies of them.

Q.—Were they made of record in any department of the State, or filed in the State House, with any one representing the government?

A.—No, Sir. They are filed in the State Engineer's office.

Q.—By whom are they signed?

A.—They are signed by the principal assistant engineer of the railroad itself, as an additional voucher. They were made up by the State Engineer.

Q.—At what time?

A.—They were made up immediately after obtaining the measurements of the line.

Q.—Did you read the contract made by the contractors with the railroad corporation?

A.—I have not since my first connection with the road. As it was not material to our particular matter, I paid no further attention to it.

Q.—Those estimates were made up without any reference to the contract made by the corporation with the contractors?

A.—Entirely. We had nothing to do, as we considered, but to see that the State's interest was properly looked to, and the money appropriated properly expended for the four items mentioned in the Act.

Q.—Then you did not assume that such a road should be built as the corporation had required of the contractors?

A.—We assumed that the road should be built as the Act specified—thoroughly and substantially.

Q.—You did not undertake to connect the Act of the legislature with the contract under which Messrs. Haupt & Co. were working when the Act was passed?

A.—No, Sir; we did not undertake to connect the two at all, the interest of the State being paramount to that of the company, the State furnishing about all the money that was used.

Q.—What was the estimated cost of the road from the Tunnel to Greenfield?

A.—That I cannot give you, without my notes. I cannot give even an approximation, for the reason that the sums paid were only for certain portions of the work.

Q.—[*By Hon. Mr. Greene.*] Is this estimate ($102,393.91) your estimate of the amount required to put the road in running order to the Tunnel, at the time of the suspension of the work?

A.—Yes, Sir.

Hon. Mr. GREENE read the estimate referred to, as follows:—

CHARLESTOWN, Sept. 12, 1861.

Estimate showing the amount of work remaining to be done upon the Troy and Greenfield Railroad, east of Hoosac Tunnel, at the time of the suspension of operations, July, 1861.

112,265	cubic yards earthwork, at 21 cents,	$23,575 65
6,261	" rock, at $1.05,	6,574 05
2,000	" loose rock, at 50 cents,	1,000 00
273	" culverts, at $3.15,	859 95
602	" vertical wall, at $2.10,	1,264 20
5,528	" rip-rap, at 78 cents,	4,311 84
3,085	" bridge masonry, at $8,	24,680 00
3,513	" tail walls, at $3.15,	11,065 95
636	" bridge superstructure, 120 ft. span, at $23.12,	14,704 32
660	" " " 60 " at $18.90,	12,474 00
4,000	feet trestling and piers, at 10½ cents,	420 00
27,898	cross-ties, at 30 cents,	8,368 80
10,000	cubic yards ballast, at 40 cents,	4,000 00
Miles of track to lay $24\frac{54}{100}$, at $472.50,		11,595 15
		$124,893 91
	Deduct value of materials delivered for bridging,	22,500 00
	Cost of putting road in running condition,	$102,393 91

I certify that the foregoing is a correct estimate of the amount of work required to be done on the Troy and Greenfield Railroad, east of Hoosac Tunnel, at the time of the suspension of the work in July, in order to place it in a condition for the safe and convenient transportation of passengers and freight, and to finish it in a manner as nearly complete and perfect as railroads usually are when opened for business.

(Signed and sworn to by) C. L. STEVENSON.

TESTIMONY OF MR. SAMUEL NOTT, *recalled.*

Q.—[*By the Governor.*] Did you make any examination of the character of the material through which the Troy and Greenfield road runs, between Greenfield and the mountain, with reference to its capacity to stand a steep slope?

A.—Yes, Sir; I noticed that point. At all the places that I went near particularly, I had an eye to that, and my opinion is, that for a large portion of the side-hill cutting, the soil is of a kind that would slip very badly; and

I noticed two or three very large slides at the time I went over a portion of the road.

Q.—[*By Hon. Mr. Baker.*] I understood you to say, yesterday, that no such material had been upon any of the roads you had been connected with; that you had worked no such material?

A.—I did not mean to say so; if I did, I made some mistake. I meant to say, that I had known about such material, and that I had met with it before; and that my opinion was, that it was very likely to slip. I think the question was, whether there was any such material on that part of the Eastern road that I was most familiar with, and I think I said that there was none. I did not recollect any at the time. But I think I also added, that I should class it very nearly with the East Boston hills. That is a very different case, however, from the hills on the Troy and Greenfield road, for the reason that the East Boston hills throw comparatively but very little water on the surface of the slope, while in the other case, the shape of the ground is such as to throw a great deal of water upon the slope.

Q.—[*By Hon. Mr. Baker.*] Would not that apply to any slope? Would not any slope be pretty sure to wash, if not protected?

A.—Yes, it would apply to any slope. But, as I stated yesterday, a slope one and a half to one would be affected very much less than a slope of one to one.

TESTIMONY OF MR. MARTIN B. INCHES, *recalled.*

Q.—[*By the Governor.*] Let me ask you the same question: What is the result of the observation you made in regard to the character of the material through which the cuttings were made?

A.—At those points that I examined, it struck me that it would wash down, and would not stand any slope steeper than one and a half to one—nor stand very well at that. There seemed to be a great deal of clay among the soil. My judgment was quite different from that of Mr. Stevenson.

TESTIMONY OF MR. GORDON H. NOTT, *recalled.*

Q.—[*By the Governor.*] What was your observation in regard to the character of the material, as to its capacity to endure a steep slope?

A.—I should think it was very poor indeed.

Q.—[*By Hon. Mr. Baker.*] How do you account for the side hills standing there?

A.—I don't think there are any less than one and a half to one. I should think they are mostly two to one, and more.

TESTIMONY OF MR. C. L. STEVENSON, *recalled.*

Q.—[*By Hon. Mr. Greene.*] Can you recollect, from the cross sections, which would tell the story conclusively, whether those hills are one to one?

A.—A few of the cross sections of the road show that they stand at an angle of forty-five degrees.

Q.—What proportion was there not so steep as one and a half to one?

A.—Most of them were more than one and a half to one. The natural slope of many of the hills would run two to one. There are some places along the river where it would be one and a half to one, and a few places where it would be forty-five degrees. The large amount of rock in the material is a great protection against the sliding of the slopes. Wherever any danger from sliding was apprehended, or where there had been slides, it will be found that the road-bed has been widened to admit of them, without injury.

The examination of witnesses was here closed.

Immediately on the conclusion of the testimony, the Governor proceeded to pronounce the following

DECISION.

Gentlemen of the Honorable Council:—

The question first arising is the proper disposition of the Order reported by the Committee of the Council, to whom was referred the Petition of the Troy and Greenfield Railroad Company, which Order, with its preamble, the Council will permit me to read.

"*Whereas,* Colonel Ezra Lincoln, the State Engineer first appointed under chapter 202 of the laws of this Commonwealth for 1860, did, in his official capacity, establish certain conditions, estimates and prices, on which the instalments of the State loan to the Troy and Greenfield Railroad Company should be paid to that corporation; and whereas, said conditions, estimates and prices were assented to by that corporation, and became the basis on which the sub-contracts for the building of the road were founded. Therefore, it is

"*Ordered,* That the State Engineer be and he is hereby directed to revise his estimates for the work done on said road in the months of May and June last, and to submit such an additional estimate as will be necessary to increase the amount already paid, to the amount which would have been paid, had his original estimates for the work done in said months of May and June been based upon the conditions, estimates and prices established by Colonel Lincoln, and that those conditions, estimates and prices shall be the basis of all future payments, until otherwise ordered by the Governor and Council."

Now, it was competent for the Committee to report any proposition which they thought to be wise; but the first question, in proposing an Order, always is, whether the Governor is satisfied that the Order itself can properly be adopted, before he can ask the Council to assent to it. A *motion* of a Councillor that the Council should advise the Governor to any particular course, in advance of the advice being asked, is not objectionable; but the *Order* could not be proposed, even, unless the Governor was satisfied, or had reason to believe that the Order, if adopted by the Council, would be one that might properly be carried out.

And, on inspecting the proposed Order, I inquire First,—granting the facts as stated,—Is the Order one which can, as matter of law, be properly adopted?

I addressed a letter to the Attorney-General, which I will read to you, with his opinion and reply, for his advice on this question.

EXECUTIVE DEPARTMENT, COUNCIL CHAMBER,
BOSTON, September 3, 1861.

Hon. DWIGHT FOSTER, *Attorney-General, &c., &c:*

SIR,—Certain questions having arisen touching the construction of the railroad between Greenfield and the Hoosac Mountain, involving points of law as well as of engineering, I beg to call your attention, in your official capacity, to the legal inquiries thus suggested.

I desire your opinion, in the general, as to the powers, duties and responsibilities of the "State Engineer," under chapter 202 of the Acts of 1860, in the execution of the trust confided to him under the third section of the Act, and especially on the question: Whether, and if at all, how far, the decisions and certificates of one month, or series of months, by him made, conclude the conscience and judgment of himself or any successor in office, in making up his decisions and certificates, for any subsequent months? Has the Engineer power, or not, at all times, in the regular performance of his duty, irrespective of what he or other engineers may have before done, to consider the practical question of the quality and substantialness of the whole work as far as it shall have been accomplished or attempted, in view of the true meaning of the requirements of the law, and of the contractors' contracts with the Troy and Greenfield Railroad Company; or, in other words, whether or not does the rendition of one monthly certificate bar all subsequent consideration of elements of calculation which either must, or may, have entered into the decision of the Engineer in making such certificate?

Please inform me whether there appears, among the documents on file, or in any other proofs accessible to your department, evidence of the establishment of any conditions, estimates and prices, by any State Engineer of the Troy and Greenfield Railroad, under the Act aforesaid, on which the instalments of the State loan should be paid to the corporation. And if there are any such prices, estimates and conditions so established, please advise me of the authority for such establishment, and its validity.

I desire also your opinion as to the power of the Governor and Council, under the Act, to direct the State Engineer to revise his estimates or submit an additional and increased estimate relating to work on which he has already passed his own judgment. Whether or not does such a power exist; and if yea, from what legislation is it derived? In like manner, please advise me whether or not the Governor and Council have any, and what, power to direct the engineer to adopt and act upon any particular conditions, prices or estimates, given to him by them, or others, as the basis of any future certificates by him to be returned to the Governor.

If your official opinion on these, or any cognate questions, has been invoked by any other person, please state the questions put, and your answer, if convenient to you to do so. And if you have had any written communication in regard to any such questions, either with Mr. Whitwell or Mr. Haupt, or both, please oblige me, if you deem it not improper by lending me the originals, or sending me copies thereof.

If any thing occurs to you as the legal adviser of the executive, justly suggested by the precise points alluded to, and which, if discussed by you, might aid the deliberations of the Governor and Council, I beg you will state it fully.

I am yours faithfully,

JOHN A. ANDREW.

ATTORNEY-GENERAL'S OFFICE, BOSTON,
September 10, 1861.

To His Excellency JOHN A. ANDREW:—

SIR,—The answers to the questions proposed to me in the communication of your Excellency, bearing date September 3d, require an examination of the 202d chapter of the statutes of 1860, which is the existing law authorizing "a loan of the State credit to enable the Troy and Greenfield Railroad Company to construct the Hoosac Tunnel."

The questions, however, have no direct connection with the operations upon the Tunnel itself, but relate solely to those provisions of this Act by which the loan of six hundred and fifty thousand dollars is appropriated to the completion of the railroad east of the Hoosac Tunnel. And they involve a consideration of the terms and conditions upon which the successive monthly instalments of this loan are to be advanced by the State; and also of the powers and duties of the State engineer, who is required to examine monthly the progress of the road, and certify the amount of scrip to the loan of which the corporation may become entitled under the act.

The following is the material section of the statute:—

> SECTION 3. The governor and council shall annually appoint a State engineer for the purpose of examining and determining monthly the amount and value of the work done and materials delivered on the railroad and tunnel of the Troy and Greenfield Railroad Company, who shall receive an annual salary of one thousand dollars, payable quarterly. The State engineer shall forthwith fix permanent marks in each end of the Hoosac Tunnel, marking the progress of the work up to February twenty-fourth, eighteen hundred and sixty, from which to determine the progress subsequently made. He shall also determine by suitable notes, marks, or observations, the amount and value of all grading, bridging, masonry or other work done, or iron or other materials delivered, on the road east of the Hoosac Tunnel prior to December twenty-second, eighteen hundred and fifty-nine, and fix data from which to determine the value of any work or materials delivered subsequent to the date last named. He shall monthly, immediately after the first day of each month, estimate the proportion which the work done upon the road since the preceding estimate bears to the whole of the work required to be done in the graduation, masonry, bridging and superstructure of said railroad east of the Hoosac Tunnel, and also the work done in the excavation of said tunnel, which he shall certify separately to the governor, together with the amount of State scrip to which the company is entitled under the provisions of this act. Such monthly estimates shall be based upon a width of road-bed at grade of fifteen feet on embankments, seventeen and a half feet in side cuts, and twenty feet in thorough cuts; in the heading of the tunnel upon dimensions fourteen feet wide and six feet high in the middle, and in the finished excavation of the tunnel of fourteen feet wide and eighteen feet high in the middle.
>
> The deliveries of scrip shall be at the rate of fifty dollars for each lineal foot of tunnel, dividing between heading and full sized tunnel, in the proportion of thirty dollars for each lineal foot of heading and twenty dollars per lineal foot for the remaining excavation; and of six hundred and fifty thousand dollars for the whole of the graduation, masonry, bridging and superstructure of the unfinished portion of the road east of the tunnel.
>
> The scrip shall be delivered on the road in the proportion which the value of the work done and the materials delivered each month bears to the estimated cost of the whole work and materials required on the portion of the road aforesaid.
>
> No expenditures shall be required merely for the purposes of ornament, but the work shall be substantially performed, and the rails shall weigh not less than fifty-six pounds to the lineal yard; for any defective materials or work a proportional amount of scrip shall be withheld.

The governor and council shall have a general supervision of the work, and for that purpose shall visit and inspect the same at least once in each year, and as much oftener as they may deem expedient; and they shall have power to correct abuses, remedy defects, and enforce requirements, by withholding scrip or imposing new requirements in such manner as the interest of the Commonwealth shall in their judgment require.

If the governor upon the receipt of the monthly estimates and certificates of the State engineer shall approve thereof, he shall transmit the same and his approval thereof to the State treasurer, and the State treasurer shall thereupon deliver the amount of scrip so certified for to the treasurer of the Troy and Greenfield Railroad Company or to his order, subject to the provisions hereafter mentioned. If he shall not approve thereof he shall submit the same to the council, and their approval transmitted to the State treasurer as aforesaid, shall authorize such delivery.

This law contemplates a loan by the State to a railroad company in aid of an enterprise of public utility. The State does not undertake to build the railroad, or determine in what precise manner it shall be constructed. Nor has the State under the Act any thing to do with the contractors whom the corporation may choose to employ. The sole object of providing for the appointment of a State Engineer is to protect the interests of the State by ascertaining, before any particular instalment of the loan is paid, that the work has so far advanced and is of such a substantial character as to furnish adequate security for the investment, and that the fractions of the entire loan, paid monthly, bear such proportion to the monthly progress of the road that the full amount will be advanced when, and not before the entire road east of the tunnel is completed in a substantial manner.

Each month the Engineer is to estimate the proportion which the work done upon the road since the preceding estimate, bears to the whole of the work required to be done; and the monthly deliveries of State scrip are to be made in the proportion which the work done and materials furnished each month bears to the estimated cost of the whole work and materials required on the portion of the railroad east of the Tunnel. For any defective material or work a proportionate amount of scrip shall be withheld.

Obviously the Engineer must determine whether the work has been substantially performed, and whether any materials or work are defective. But he does this only incidentally, to ensure a railroad of such character as will give the State adequate security for its monthly advances, and by no means for the purpose of finally accepting any part of the work in behalf of the State. Still less is he empowered to make a contract with reference to the character of the entire road, which can in any way bind the future action of the State, of his successors, or even of himself. The only contract of the State is to be found in the statute. He is not to wait till a particular portion of the work is completed before he awards upon it an issue of scrip, but the loan is to be advanced upon unfinished work as well as finished.

If any work has been treated as substantially performed, either by the former or the present Engineer, and is subsequently ascertained to be defective and not substantially performed, it is the duty of the Engineer to withhold a proportionate amount of the scrip; and in my opinion it can make no difference whether a latent defect in the work or materials has been discovered, or whether a mistake of the Engineer has caused too much to be advanced at any former period. Of course previous advances cannot be recalled, but each month's estimate requires the Engineer to determine how much remains to be done to complete the entire road in a substantial manner, and then he certifies that the corporation is entitled to the issue of such an amount of scrip as the cost and value of the work done and materials furnished in a given month, bears to the cost and value of all remaining to be done and furnished.

All this he must do upon his professional and official responsibility, in the discreet and conscientious exercise of his personal skill and judgment.

It is no more competent to the Governor and Council to instruct the State Engineer what he shall treat as substantial work and substantial materials, than to direct any other public officer clothed with a trust how he must decide and act within the sphere of his official duties. The supervision given to the Governor and Council, and the power to correct abuses and enforce requirements, is designed as an additional safeguard against the improvident issue of too large portions of the loan, but by no means to enable them to issue greater amounts than the Engineer certifies to be due. And they can no more order him what certificate to make than they can order any other public officer to come to a conclusion contrary to his own judgment in a matter in which that judgment is by law supreme.

The remedy, if he commits errors, or is guilty of arbitrary conduct, is to be found in his removal from office, or an application to the legislature for redress.

The question, what constitutes a substantially built road, such as the law demands, is one addressed purely to him as an Engineer; and he ought to require a road ordinarily well built, according to the existing standard of good work in similar locations, constructed by competent engineers at the present day. With the question, whether such a railroad will cost more or less than six hundred and fifty thousand dollars, the State Engineer has nothing to do. The State has agreed to lend that sum upon such a road in monthly instalments, proportioned to the progress of its construction. It is his duty to make each monthly estimate on these principles. And if in former months he or his predecessors have been too liberal, or not liberal enough in estimating the work, he must nevertheless now make the following inquiries:—

How much remains to be done and furnished in order to complete this railroad substantially, and what will it cost?

How much has been done and furnished during the last month for which I am now making an estimate, and what has it cost?

How much of the State loan remains to be advanced?

A proportion stated on these principles will ascertain the amount of the monthly issue for which the Engineer is to make his certificate.

The particular questions which have been made as to details are, with one exception, matters of engineering and not of law.

I am of opinion, however, as a matter of law, that this portion of the railroad cannot be considered by the State Engineer as finished so long as any thing remains to be done upon it which the railroad company has required to be done by the contractors.

The statute speaks of the whole of the work required to be done in the graduation, masonry, bridging and superstructure of the railroad east of the Hoosac Tunnel. The existing contract between the Troy and Greenfield Railroad Company and the parties who have undertaken to build the road contains the following stipulations: "If any trestle-work or temporary bridging should be used in the construction of the road, this also shall be changed by and at the cost of the contractors, and replaced by permanent structures as soon as practicable after the completion and opening of the whole line."

Certainly as between the corporation and the contractors, the latter cannot claim that the portion of the road east of the Tunnel is finished until such permanent structures have been supplied; and I do not think the State Engineer at liberty to treat this portion of the road as completed for the purposes of the loan so long as any part of the work remains undone which the corporation requires of its contractors as a part of their contract of construction.

My opinion upon some of the questions which I have thus considered, was asked by the State Engineer in a communication received from him in July, which at the request of your Excellency I herewith inclose.* I thereupon wrote a note to Herman Haupt, Esq., on the subject, which, with his reply, I also inclose.† The substance of the answer received from him was by my clerk communicated to the State Engineer, and in consequence of it I did not prepare the opinion which had been called for, as it no longer seemed of immediate importance to either party during the suspension of work by the contractors. I had shortly afterwards an interview with Mr. Haupt at my office for the purpose of ascertaining his views on the different topics upon which my opinion had been desired, in order that I might not fail to consider all the aspects favorable to him of a subject in which he was deeply interested.

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* See Appendix, B.

† See Appendix, C.

I have never seen any paper and am not aware of the existence of any purporting to establish a basis of estimates, conditions, or prices which should govern the contractors and determine the quality of the work upon the road which was agreed to be received as satisfactory by any of the State Engineers. And I have already expressed the opinion, that no State Engineer could establish, either on behalf of the Commonwealth, or the Railroad Corporation, any such standard, or determine any thing beyond the simple question, how much of the loan the corporation was legally entitled to receive for the work done and materials furnished during each month singly, and that there neither is nor can be any contract binding the Commonwealth in the premises except the one contained in the statute.

I believe the foregoing opinion discusses all the topics which are referred to in the letter of your Excellency, and I have the honor to be,

Very respectfully, your obedient servant,

DWIGHT FOSTER, *Attorney-General.*

I have no manner of doubt myself, nor had I beforehand, from my own investigations, that such was the law. I cannot believe that the Governor and Council have any power to direct the findings of the State Engineer, to bind his judgment or conscience.

The next question is of a practical as well as a legal character, viz.: Can and ought any step to be taken by the Governor and Council, within their competency under the law, with a view to causing the issue of scrip contrary to the findings and certificate of Mr. Whitwell, the State Engineer? There is one way in which the result could be arrived at, and that is by the removal of Mr. Whitwell. But that can only be done by the Governor taking the initiative. I am never unwilling to bear any responsibility properly pertaining to me, in whatever place I find myself in the natural order of events. I would never seek any responsibility, of any sort, voluntarily; but I hope I shall never be willing to avoid any responsibility which my duty imposes upon me. And I am clear in my own mind, that whether I will or not, the responsibility of a decision of this matter in its present phase, rests at last upon myself personally; that I cannot shoulder the load upon any body else, although I would gladly do so; and I greatly regret that the legislature is not now in session, in order that the subject might be immediately referred to the law-making power. All difficulty could be met, so far as it lies in the minds of Mr. Haupt and his friends, and his purpose be served, with entire ease, by removing Mr. Whitwell and appointing somebody else, of whom I might know beforehand that his opinions would coincide with Mr. Haupt's. But, in order to be *justified* in doing that, I must be first satisfied that Mr. Whitwell is wrong and that Mr. Haupt is right. Because, the moment I should take any such step, I should become the positive defender of that set of opinions which Mr. Whitwell does not sustain. Now I confess that as to all the practical questions that have arisen in reference to this subject, I not only had no opinion in advance, but I had never heard of any such questions in relation to any railroad. The question never happened to arise in my mind, and I never heard it raised any where, "What is the proper slope of a railroad cutting?" nor whether the trestle-work ought to be filled up with embankment, in order to constitute a proper completion of a railway; nor did I ever hear of the difference between the Haupt bridge and the Howe bridge, or any body's else bridge,—and therefore I did not come to the consideration of any of these practical inquiries with any preparation derived from education, to enable me to form, and rightfully to entertain and act upon a judgment independent of the opinions of other men possessing education and experience in the practical science of railway engineering. I must therefore look at the whole subject in the same judicial manner in which a person having the duty of decision is obliged to regard and treat evidence.

In the first place, I suppose that it is not to be assumed that the State Engineer is wrong. The moment his opinion is challenged by any body having a right to dispute it, it becomes, for the purpose of inquiry and investigation, an open question; Whether he is right or wrong? He may be wrong; but still, he may be right. Which is the truth? I do not know, save as I am instructed from sources of information outside of my own studies and my own education, and my own experience. Thus it becomes important to take the testimony of other men, in addition to the testimony of the State Engineer, with a view to ascertain whether his opinion is sustained by others having a right to say that they know, and on whose judgment we ought to rely. If the opinion of such men was decidedly and affirmatively in oposition to that of Mr. Whitwell, it might relieve my mind of all difficulty—if he stood singular and alone, or in a very small minority. But we have swept a drag-net through the community, and have drawn in a large number of most intelligent railroad engineers, managers and experts,—all of whom, on grounds of experience, observation and science, unite in maintaining his opinions and sustaining his conclusions. If opinion was *balanced*, even, so that after having heard them all, I was obliged to say, "I remain in doubt, and know as little about it as I did when I commenced the investigation," I should still hesitate to take any step of my own, since to take the step would be to imply knowledge and an intelligent opinion. One party might be right, and the other party might as well be right, for aught that would be known to me. But I think the investigation we have had, very clearly establishes an entire concurrence of railroad experts with the principles, theories and opinions advanced by Mr. Whitwell.

But then another question may be suggested, to wit: Is there nothing peculiar, in reference to this Troy and Greenfield Railroad,—or that part of it lying east of the Hoosac Mountain,—which takes it out of the category of ordinary New England or Massachusetts railways? If there is any such thing, it ought affirmatively, and, by clear evidence, to appear. Such exceptional character is not to be presumed. The presumption is, that it is to be regarded, in all respects, like other railroads built in Massachusetts. And that presumption is re-enforced by the testimony of Messrs. Samuel Nott, Gordon Nott, and Mr. Inches, who have carefully examined the whole route. We may also derive great assistance on this point by considering the whole subject a little in view of its own history. We are acting under the direction and authority, and supreme control, of an Act of the Legislature. We are bound to obey the law. We cannot make it; we have no right to bend it; we have no authority, nor would it be just, to attempt a stretch of power that would enable me or any one else, to act in view of a preconception or private wish of our own. We must administer the law just as we find it; and in this respect we are *judges* and not *legislators*. The Act in question was passed recently—only so far back as the year 1860; and the section by which we are now particularly controlled is that cited in the opinion of the Attorney-General, and which I have just read, in the 202d chapter of the laws of that year. Now, I think it is not only clear that the legislature must, in speaking of a railroad and of the construction of a railroad, in Massachusetts—except in so far as they indicate an intention of departure—must not only have intended and understood a railroad, just like others accustomed to be built here, in Massachusetts, but they must also be supposed to have had in mind the peculiarities and the history of this very road which was then in process of partial construction. They speak of the "Troy and Greenfield Railroad Corporation," and it cannot have escaped the attention of the legislature that a formal contract, in writing, had been previously made between the Troy and Greenfield Railroad Company and the firm of Herman Haupt & Co., as contractors. Not only that, but we know that a committee of the legislature investigated the condition and affairs of the Troy and Greenfield Railroad during that very session of 1860; that this committee made a report, which is found in print among the documents of the House, (House Doc., No. 185,) in which they referred to that contract, and to which they annexed the contract there found, set out and printed in full. It thereby came to the notice and observation of every member of the general court who voted on the loan Act, and of the governor who approved it; and therefore I cannot resist the conclusion, that when the legislature agreed to loan $650,000 to aid the construction of this road, they had in view such a road as the Troy and Greenfield Railroad Company had contracted with Mr. Haupt & Co. to build. If we recur a moment to the contract, we find in it this agreement: "The said contracting parties, under the name, firm and style of H. Haupt & Co., do hereby promise and agree with the said Troy and Greenfield Railroad Company, to make, construct, build, furnish, *in every respect complete and in the most substantial and workmanlike manner*, the Troy and Greenfield Railroad." And I find, also, in the agreement, the clause referred to and recited by the attorney-general in his opinion, relative to the filling up of trestle-work with solid embankment. So that the road to which the legislature agreed to lend money was the Troy and Greenfield Railroad, to be built "*in the most substantial and workmanlike manner.*" And, therefore, when the legislature came to use the phrase, "*the work shall be substantially performed,*" I suppose they meant the work which it was requisite to do in order to complete this railroad in "the most substantial and workmanlike manner," as it was agreed it should be done in the then existing contract.

The phraseology adopted by the legislature, however, derives additional illustration and meaning from another phrase in the context:—"No expenditure shall be required *merely for purposes of ornament*, but the work shall be *substantially performed.*" Now, the juxtaposition of the idea of *substantial* performance with the idea of *ornamental* performance, lends us aid in understanding what substantial performance was intended to mean. I suppose, therefore, the legislature meant, "You must do whatever is needful to the construction of a substantial road, but stopping short of ornament." If we say, "You may stop somewhere this side of stopping short of ornament," we shall then put a different construction upon the phrase "substantially performed," from that adopted by the Legislature.

But the principles upon which it is demanded that we shall issue the scrip, do not recognize, at all, these obligations imposed by the presumption that the Act of the Legislature had in view the kind of railway Mr. Haupt had contracted to build. And Mr. Stevenson in his testimony expressly admits that the contractors and the State Engineers who preceded Mr. Whitwell did not regard these terms of the contract, but on the contrary assumed in their own minds a kind of road such as they thought it wise to build in view of the money to be disbursed by the State, and the scanty means of the corporation.

Then, in the light of the testimony we have had, can I in conscience say that I believe Mr. Whitwell is wrong in requiring that the slopes should be reduced, that the trestle-work should be filled with embankments, and that the bridge should be made stronger, or at least, should be more thoroughly tested, before the road and the bridge can be called complete? I think not. I think that the testimony of Mr. Stevenson this morning, in and of itself, settles that question; because

Mr. Stevenson does not differ from the other engineers whose testimony has been taken, in regard to the principles adopted by Mr. Whitwell; even he does not undertake to say that these slopes should always be left as they are; nor does he pretend that the trestle-work is intended always to be left as it is; nor does any body pretend that the bridge is perfect as it is; but all agree that something more remains to be done to the bridge, the trestle-work remains to be filled, and the slopes remain to be reduced. Of these three propositions there can be no doubt. That being so, the question whether, as a matter of prudence on the part of the owners of the road, —to wit, the Troy and Greenfield Railroad Corporation—it is better that the road should be put into operation while the construction remains to this extent incomplete, is not a question which arises here? And, I think, the mistake of Mr. Stevenson is in supposing that this particular question does arise here and now, and before the governor and council. That is wholly for the determination of the proprietors of the road—to wit, the Troy and Greenfield Railroad Company. The only ultimate question which *we* have to settle is,—Whether the $650,000, or a certain proportion of that sum, has been earned up to the present time. And it is no answer to say to the State Engineer, (if he objects to allowing the issue of scrip because certain things remain undone,) "True; but we will do these things by and by." This scrip is to be issued only in the proportion in which the work is *performed*. And I think there is a confusion in the minds of gentlemen sometimes in relation to the whole subject. We forget that the State has simply undertaken to furnish means by way of a loan to a railroad corporation, and are found considering the subject in the same manner as if the Commonwealth was itself the railroad company, doing its own work and performing the functions needful to a successful and prudent accomplishment of the railway as its own work. I confess I do not wonder we sometimes fall into that mistake, for it is true that nearly all the funds contributed to the work are derived from the State loan; but that fact does not alter the legal attitude of the case; and it does not alter our rights or our duties in reference to that attitude. And I am free also to say, that had I been acting in the capacity of a legislator in the year 1860, it seems to me I should have found great difficulty in the loan on the principles of this Act; that I should have been disposed to have taken the work out of the hands of the corporation, and to have had it performed by the State, unless it should have appeared that the work was one of impossibility or of manifest inexpediency to be performed at all. I always like to have every thing *seem* to be just exactly *what it is.* And the difficulty with the present case is, that it *is* one thing, and *seems* another; and seems so much *like* the other, that every body is liable to be misled. So, consequently, we are addressed by the argument, that to decide according to the law and the facts, involves, or may involve, a loss to the State by the temporary suspension of an enterprise which is assumed to be, in substance, solely its own. Well, I greatly fear that the decision may involve an apparent loss to the State; and I greatly regret to be driven into the necessity of violating the law on the one hand, or of incurring the possibility of present apparent loss to the Commonwealth on the other, besides calling down upon myself the personal odium which may attach to me as the result. Still, that reluctance to meet a responsibility will not justify me in attempting to evade it.

The result to which my mind comes is this, viz.:—I do not find on the evidence that Mr. Whitwell's conclusions are wrong as to the facts of practical science in railroad engineering involved in those conclusions; nor that he has misinterpreted the law. That being so, were I to remove him, and nominate somebody else, with a view to the adoption of a different course of policy, by another engineer, I should be assisting, voluntarily and actively, in carrying out a policy which does not seem to me to be sustained. I am comforted a little in this conclusion as to what my duty is, by the very petition, signed by a large number of most respectable citizens interested in this road, and headed by an old friend of mine, Hon. Carver Hotchkiss, of Shelburne Falls, recently a Senator, whose keen sense and good judgment I have oftentimes had occasion to observe, and which I think are very clearly illustrated by the character of the memorial headed by his name. This petition, thus largely signed, is directly addressed to me, asking for the removal of Mr. Whitwell. I think he saw clearly, as I see, that there was no other way of righting the wrong which I presume he supposed existed.

Mr. Haupt has written to me, within two or three days, a letter of considerable significance.

ENGINEER'S OFFICE TROY AND GREENFIELD R. R. AND
HOOSAC TUNNEL, Philad., Sept. 21, 1861.

To His Excellency J. A. ANDREW.

SIR,—In addition to previous statements I think it necessary to inform your Excellency that I have no idea of abandoning the work on the Troy and Greenfield Railroad and Hoosac Tunnel so long as there is a possibility by any means of procuring capital for its prosecution and completion.

I do not now expect to resume work this Fall because the delay in the action of the State authorities renders it impossible to complete the bridge across the Deerfield near Bardwell's Ferry before winter, and if not completed it would be almost sure to be carried away by ice. I do not think, however, that the early resumption of the work has any connection with the question now under consideration by the Council. If we are not entitled to the $100,000 claimed we should not receive it; if we are entitled to it, it is for work already done, and good faith requires its payment.

I will further state, that so far as I am individually concerned, the payment or refusal of the amount claimed is of little consequence; not a dollar of it would rest in my hands: all, and more, is due to sub-contractors and to parties, most of them citizens of Massachusetts, who have furnished materials and done work; they, not we, must bear the pecuniary loss. What we suffer is the loss of a credit that has never heretofore been impaired, and the mortification of being unable to meet engagements. I have sacrificed much to carry through the great work with which I am connected. My mistake has been, not in underrating the difficulties which nature has interposed, but in an overestimate of the willingness or ability of citizens of Massachusetts to fulfil engagements. The Railroad Corporation could not raise the money required by their contract, stockholders would not pay subscriptions without compulsion, State authorities have been sometimes hostile or exacting, and since I set foot in the State I have been engaged in an incessant contest with financial difficulties and political, individual and corporate opposition. The problem for my solution was a practical one; it was with the means and resources at my command to complete the work which I had undertaken; my efforts were taxed to the utmost limit before the change of State Engineer introduced a new, arbitrary and unnecessary standard which rendered further progress impossible. To have applied to the Governor and Council for relief before stopping the work would have been out of the question. I could not carry on work involving an expenditure of more than $1,000 per day while waiting for their action. I was confident that you would sustain your engineer, and I was satisfied that with the views of that engineer I could not continue the work. Believing Mr. Whitwell to be honest, I have too much respect for myself to ask him to modify his estimates in opposition to his convictions of duty, and if he had been willing to do it to gratify me I would have ceased to entertain any respect for him.

Six weeks more of good weather with the forces on the line at the time of the suspension would complete the grading to the east end of the Tunnel; the iron is all delivered, and an expenditure of $90,000 would put the road in good running order, not perhaps in conformity to Mr. Whitwell's standard, but fully up to the standard of Messrs. Thomson, Latrobe, and other eminent practical engineers.

I desire again to direct attention to the importance of employing a suitable person to protect the work as well as it can be done before winter, to avoid greater losses than have already been incurred by the suspension.

Very respectfully submitted.

H. Haupt.

Mr. Haupt, also, in several other letters, and especially in a printed communication under date of July 23d, (published in the newspapers, and in reply to a communication from the Hon. George Grinnell, and several other of the leading citizens of Greenfield,) has stated his views in such a manner as to lead me to the conclusion, that it is hardly possible, without additional legislation, granting more aid from the State, or assistance from private parties by the taking up of stock, to expect him to carry on and carry out this work, even had Mr. Whitwell's opinions agreed with Mr. Stevenson's. He remarks in his letter to Mr. Grinnell and others :—

"To enable the contractors to resume and complete the work, the following, or some equivalent arrangements would be necessary.

1. The payment of the balance of the $650,000 appropriated by the State to the completion of the road, without reducing the amount by any further payments on account of interest or sinking fund.

2. The delivery of the scrip of the towns when the conditions of the town votes shall have been substantially complied with, and some guarantee that this will be done.

3. The Cutlery Manufacturing Company at Shelburne Falls, who are more interested in the completion of the road than all other parties

between Greenfield and the Tunnel, should pay their subscription in cash, or negotiable paper, and look to the railroad company for payment of their claims for land damages and services.

4. Land owners should wait until the road is completed and then collect their awards with interest from the railroad company, not from contractors.

If in addition to this the Fitchburg and Vermont and Massachusetts Railroad Companies, or the Connecticut River Railroad Company, or any other parties would advance, say $50,000 as a loan, to be reimbursed by appropriating the whole of the receipts of the road over working expenses, until the same shall be repaid, a sufficient amount could thus be provided to resume work on the tunnel and complete the railroad."

In one of his communications, Mr. Haupt states an additional difficulty, and that is, the reduction of the market value of the Massachusetts State Scrip, which, issued to him at the rate of one hundred cents on the dollar, sold in the markets of Europe, I think, for one hundred and ten cents on the dollar; but which is now, by the monetary and political convulsions of the country, reduced to something between eighty and ninety cents, making a net loss, as he reports, of twenty-three per cent. Besides, he has been disappointed by the failure of the City of Boston to subscribe half a million of dollars to the enterprise, on which he had depended. These seem to be a fatal accumulation of embarrassments; and if we were to attempt to break or stretch the law, for the purpose of assisting him in continuing his enterprise, it seems to me quite clear, upon his own showing, that the enterprise could not be long continued without the aid of legislation, and would come to a pause unless the citizens of the Commonwealth should become so far convinced of the usefulness and profit of a railroad from Greenfield up to the Hoosac Mountain as to make them willing to subscribe for its stock. And it seems to me quite surprising that since every one knows that the *railroad* can be built, while a great many people doubt the feasibility of constructing the *tunnel* through the Hoosac Mountain, that, with $650,000 subscribed on the part of the State as a loan, citizens interested in the prosecution of the enterprise are not willing to contribute the small amount of money necessary to complete the railway.

Hon. Mr. BAKER.—All these statements are made after the work was stopped, and their own credit had become worthless?

The Governor.—Yes; after they had stopped. Before stopping there was no occasion to make such statements.

Hon. Mr. Baker.—But I think that alters the face of it.

The Governor.—All these difficulties accumulated in the present, or threatening in the immediate future, lead me to the very strong belief that nothing short of legislation, or a rallying of the pockets of the people, will save the enterprise. I very heartily regret the possibility of injury to the work by its being left in its present predicament; that the corporation to which the State has loaned its money is so poor that it is wholly dependent upon the State for the means to save the embankments of the road from injury by the freshets of the Deerfield River and the frosts of spring. And if there is any method open to us by which we can prevent such injury, I certainly shall unite with every one in putting that method into the earliest possible operation. I do not see why the railroad corporation, which alone has power to act—we have the power only to issue scrip, and that *sub conditione*—may not intervene and go on with the work, if we will issue scrip to pay for it, and protect these embankments by rip-rapping, or other necessary process. If they will not proceed, we have no power to compel them to proceed, nor do I know that the State has any power to enter upon the road, excepting for condition broken in the mortgage by which the road is pledged to the State to secure its loans. If the State is obliged to enter for condition broken, I suppose then it is open to the Commonwealth to proceed according to its own judgment of its own interests; but the question whether the governor and council would have any power to proceed is an inquiry I have not considered. I should of course, with great readiness, if the power is open to us, coöperate in whatever is necessary for the purpose of saving the property and saving the enterprise itself from loss. I greatly fear, however, that possibly nothing remains, unless the railroad corporation itself will proceed to protect the embankments and allow us to issue scrip to pay for the expense it may involve, except to await the action of the legislature. I need not repeat the expression of the regret I feel that the legislature is not now here to do its own appropriate work.

This question, I am very happy to know—and, under the heavy weight of responsibility which is imposed upon me, it gives me great consolation to know—does not at all affect the grand enterprise of tunnelling the mountain; nor do any opinions, whether of engineers or others,—certainly, no opinions of mine—relate to, bear upon, or prejudice, any judgment in relation to the ultimate completion of that enterprise. The Commonwealth itself seems to have repeatedly expressed its confidence in its feasibility, its propriety, and its usefulness; and since I always endeavor to make it a rule to have no opinions—certainly, to express no opinions—upon subjects which I do not understand, far be it from me to express doubts of the correctness of the opinions of any who on intelligent and scientific examination entertain a conviction of its ultimate success. Certainly, it is one which challenges admiration, and which every ardent and aspiring citizen—every ardent man at least—would strive to believe in and desire to realize; and if it is the opinion of those who direct the legislation of the State that the Commonwealth ought to take it in hand, in the absence of its being taken up by private capital, the time is not far off when the general court will be sitting in the State House, and in the proper exercise of its peculiar functions can do what our powers fail to authorize.

I am sorry to have detained you, gentlemen, by saying so much; but I thought it proper to go over the matter somewhat fully; and, as it had been elaborately discussed in arguments before the Committee, and in the elaborate Report of the Committee itself, I did not see how I could do justice to it, or properly perform my duty to the Council without as clear and explicit a statement of all my views and reflections as I was able to make. Pronouncing this opinion immediately on the close of the hearing of the testimony—now fresh in the memory of all of us—I have avoided its recapitulation. But I may be allowed to remark that it can scarcely be possible to imagine a case in which the professional mind of a large array of learned and most experienced experts in any science could be found more consistently and unanimously harmonious. Not even Mr. Stevenson dissents from their opinions; nor does he seek to justify the departure from their practical application except as a temporary expedient. But *we* have no right to resort to any expedient. The corporation has a right to do so. But the corporation cannot ask us to deliver the scrip of the State, which is lawfully issuable on the actual *performance* of substantial work in the best and most workmanlike manner, before it has been performed, and while it is only contemplated and may never be accomplished.

Now, if any gentleman can propose a measure which will secure this work against injury by the action of the river and frosts, I shall be most happy to entertain the proposition. According to Mr. Haupt's letter, that is the only thing remaining of possible performance, at present.

And, if on any of the questions of law suggested in these remarks, the Council shall hesitate, I will, at the request of the council, unite with that honorable body, in seeking the opinion of the Supreme Judicial Court for our common instruction. Since I cannot pretend to any doubts on my own part, nor to any want of confidence in the aid derived from our proper legal adviser, the attorney-general, I cannot invoke the opinions of the Court, even were it competent for me to do so, alone. But the governor and council may approach the bench with appropriate inquiries, and my respect for your scruples and wishes would forbid my refusal to join you in seeking instruction from that source of the highest judicial authority, to whose judgment, in these premises, I should respectfully yield my own opinion and conform my official conduct.

The results of my own reflection and observation are as follows:—

First.—That the Order reported by the Committee is legally inadmissable. The Engineer is clothed with a trust which he must fulfil according to his own conscience and intelligence, and he cannot be directed by us what to report.

Second.—The object aimed at by the Committee can be accomplished only by the removal of the Engineer, and the appointment of another one known in advance to favor the views of Mr. Haupt and not those of Mr. Whitwell.

Third.—This can only be done by the Governor taking the initiative in the exercise of the power of removal and appointment. And before I can rightfully exert this power I ought to be convinced that Mr. Whitwell is wrong and Mr. Haupt is right.

Fourth.—But the proofs drawn from the opinions and testimony of experts, in the application of engineering science to the construction of railways, clearly demonstrate that Mr. Whitwell has only followed well established general rules of his profession. Nor is it proved that any reasons exist rendering this road an exception to those rules.

Fifth.—It is urged that Mr. Haupt has constructed this road consulting all possible economy of construction consistent with despatch in putting it into operation, expecting to perfect its details out of earnings thereby to be secured. While of this course on his part we have no right to complain, so long as it meets the approval of the railway company who employed him, yet the issue of State Scrip is regulated by the *statute*, and not by any such policy or convenience.

It is not for us to ask, how, by any economy, $650,000 can be so distributed as to build a road capable of use? But we are to issue scrip simply on the strength of what is actually done and accomplished in a thorough, substantial, and workmanlike manner.

APPENDIX.

[A.]

BOSTON, July 25, 1861.

To His Excellency JOHN A. ANDREW:

SIR,—The course pursued by H. Haupt & Co., contractors on the Troy and Greenfield Railroad and Tunnel, in suspending their work in consequence of certain decisions of the State Engineer, demands from me a plain statement of the facts in the case, and the reasons for those decisions.

In a circular lately issued by Mr. Haupt, the principal contractor, the State Engineer is charged with changing the policy of the road, and the prices for the work as established by his predecessors—as if certain prices, and a fixed policy had been mutually agreed upon by the contractors and the former engineer, which was in no event to be changed.

If a policy and system of prices to be adhered to during the construction of the work were established by the first engineer, I have seen no written evidence of them. A paper has been delivered to me which is said to be an approximate estimate, made out by Mr. Lincoln, of each amount of work required to finish the road, with certain prices attached, which make the total cost of the road $650,000. This paper has no signature, and there is no evidence to show that it was intended to be binding upon either party, or that it was other than a memorandum for the convenience of Mr. Lincoln in making out his estimates. Had such a paper been correctly made, referred to in the Act, and adhered to with any degree of strictness in the construction of the road, no change could have taken place in the prices, and the work, remaining to be done, would have always been found, by deducting from the whole work of the road as shown by this paper, the amount of work done—whereas, even supposing this paper had been intended for a guide, the plan of construction has been so changed by the contractors themselves, that the quantities have changed very materially, and are changing from month to month, as the progress of the work exhibits with more accuracy its true cost and requirements—and Mr. Haupt well knows that the prices have never been considered permanent, but have been frequently changed, as the quantity of work to be done was found larger than was at first supposed.

Taking the Act of 1860 as a guide, which says that the road shall be *substantially* built, I think it was the policy and intention of the State to have a *well-built road*, and that the money advanced should only *aid* in its construction, and not be sufficient for its completion; and that whatever sum the road should cost in addition to that advanced by the State should be furnished by the contractors, or by private subscription.

Mr. Haupt's construction of the policy of the State, and one by which he wishes the engineer to be governed, seems to be, that the State was to lend him $650,000, and that he in return was to build a road of the cheapest class—the State advancing the money as the work progressed, and taking all the risk of new and untried bridges, insecure embankments, and the failure of the contractors.

If such had been the policy of the State to advance money upon the security of an unfinished road, the actual cost of which when the rails were laid would be no more than the loan, and to depend upon the good faith of the contractors to complete it from the surplus of the receipts over the running expenses, in preference to appropriating it to their own benefit, it would certainly have been stated in the Act with clearness and precision.

Soon after receiving my appointment, and about the 8th of June, the Attorney-General had decided that the estimate of work done for June 1st, prepared by Mr. Stevenson, the late engineer, could not be accepted, as his term of office had expired on the 25th of May. A new estimate was therefore to be made with as much dispatch as possible, to prevent inconvenience to the sub-contractors, who were expecting their monthly payments.

In order to meet the wishes of Messrs. Haupt & Co., who urged the necessity of having an estimate ready for the 15th, I went over the work with as much rapidity as possible, making notes. Upon a revision of these notes, it was found that the examination had been too rapid, and could only be used in aid of one more carefully conducted, which would be necessary before a reliable estimate could be made.

A few days after, having engaged the services of an assistant of long practical experience on railroads, I went again to Greenfield, and starting from that place, passed over the whole line, with the exception of two sections that were unimportant, making notes and measurements wherever necessary. My companion starting from the western end of the road, examined the whole twenty-nine and one-half miles, counting all the sleepers and rails, and making similar notes and measurements.

Upon our return to Greenfield, these notes were carefully compared, and from them and the returns of the engineers of the road, a table of all the work done, materials delivered, and of all the work remaining to be done was made up. From this table the estimate of the 1st of June was prepared. In most cases the statement of the assistant of the amount of work to be done was reduced by me, which had the effect of increasing the amount due to the contractor.

This examination having been made nearly at the close of the month, no other was required for the 1st of July, which was made up with the aid of the returns of the engineers, and of another visit to Greenfield to ascertain the accuracy of those returns in some important particulars.

I have been thus minute in mentioning the care bestowed to arrive at results, which seem to have given so little satisfaction, because the impression has been given that the examinations were not made by me in person, and that the returns of those I had employed had been arbitrarily cut down.

It was my intention at the close of the month to have made a still more careful examination, by which any previous errors could have been corrected, but the suspension of the work seems to render that now unnecessary.

I need not say that I entered upon my duties without instructions, and with no other guide than that of the Act of 1860 passed in favor of the Troy and Greenfield Railroad. This Act, from its want of the proper specifications, defining with exactness the manner of building the road, throws great power and responsibility into the hands of the engineer. Allow me to quote some of the principal clauses pertinent to the subject.

The Act provides that the "engineer shall monthly estimate the proportion which the work done upon the road since the preceding estimate bears to the whole of the work required to be done in the grading, masonry, &c.

"That the deliveries of scrip shall be at the rate of six hundred and fifty thousand dollars for the whole of the graduation, masonry, bridging and superstructure of the unfinished portion of the road east of the Tunnel.

"That the scrip shall be delivered on the road in the proportion which the value of the work done and materials delivered each month bears to the estimated cost of the whole work and materials required on the portion of the road aforesaid.

"No expenditures shall be required merely for ornament, but the work shall be *substantially* performed, and the rails shall weigh not less than fifty-six pounds to the lineal yard; for any defective materials or work, a proportionate amount of scrip shall be withheld.

"The Governor and Council shall have a general supervision of the work; and they shall have power to correct abuses, remedy defects and enforce requirements, by withholding scrip or imposing new requirements, in such manner as the interests of the Commonwealth shall in their judgment require."

That the application of the Act may be better understood, it will be necessary to explain the manner of making the estimates.

At the beginning of each month, the whole work done and that remaining to be done, is carefully measured, and these added together make up the whole amount of work upon the road when finished: such prices are then apportioned to each kind of work with reference to its actual cost, that when multiplied together, the sum shall amount to $650,000. These prices so apportioned, are then multiplied by the different amounts of the same kinds of work done up to the first of each month, and the sum after deducting previous payments, constitutes the amount due to the contractor.

It is evident, then, that the first and most important question for the engineer is, to decide what shall the character of the road be to fulfil the requirements of the law—and for this he must have recourse to his own construction of the Act.

The Act says that the road shall be substantially built, and in the absence of any more specific instructions, this must mean, that it shall be built in accordance with the rules, and in the style of ordinary roads of the present day—this would require side slopes in the cuttings of an inclination of one and a half feet horizontal to one foot vertical—that all ravines should be filled up by embankments, and not bridged over with trestle-work.

That embankments exposed to the washing of the river should be thoroughly rip-rapped or covered with loose rock taken from the excavation—and that the track should be properly ballasted. Upon an examination of the road I find that it is located for a great portion of the way upon a steep side-hill, very liable to slide by the action of the frost—that the side slopes are only on an inclination of one to one or forty-five degrees—which is less than those of the Boston and Worcester, Old Colony, Cheshire, Vermont and Massachusetts, Fitchburg, and other roads in this vicinity; that much of the embankment is made upon the side of the river, and exposed to the spring freshets, which must cause each year a serious loss and heavy repairs, unless very thoroughly covered with a coating of loose rock—that but little of the track is properly ballasted with gravel, and that many deep ravines are bridged over with wood, instead of being filled with embankments of earth. Upon reference to the first contract made with Messrs. Haupt & Co. and the Troy and Greenfield Railroad, which contract, though now cancelled, will show what was originally intended, it will be seen that Messrs. Haupt & Co. "agree to make, construct, build and furnish, in every respect complete and in the most substantial and workmanlike manner, the Troy and Greenfield Railroad"—and in the present contract, although this sentence is omitted, there is nothing to contradict any such interpretation of the contract, and taken with the former contract, it may be implied—but it is expressly stated in the last contract "that if any trestle-work or temporary bridging should be used in the construction of the road-this shall be changed by and at the cost of the contractor, and replaced by permanent structures as soon as practicable after the completion and opening of the whole line."

The enforcement of this latter clause is one of the principal reasons for the charge of Mr. Haupt that there has been an entire change in the policy established by the former engineers, but this clause shows conclusively that trestling over the ravines was considered only a temporary construction, and that to complete the road in these places, a large amount of work would be required after the laying of the rails, and for which a sum sufficient to cover its cost should be retained from the contractors. Upon this principle I have added to the amount of work heretofore thought necessary to finish the road the requisite quantity of materials for filling up the ravines, taking out the slopes, protecting the banks, and ballasting the road.

The bridging constitutes a large item of cost on this road, and as nearly all the materials have been delivered on the line of the road, if paid for at their full cost, a small sum only would be left for their erection and restoration in case of failure. The plan of these bridges is not the one I should have recommended, but having been allowed by the former engineer, and the work being now in a very forward state, it would be manifestly unjust to insist upon any radical change without giving the contractors every opportunity to make the bridge as thorough and complete as they may think necessary. The failure of one of the spans, a short time since, when tested by some loaded cars, the contractors ascribe to the use of cast-iron, where they have since in this particular span been substituting wrought iron; they have also been putting in an additional quantity of iron rods, and in other ways adding to its strength; but the bridge having failed once, is certainly a sufficient reason for the State to look upon it with suspicion, so far as to induce more than usual caution in making the monthly advances. For this reason I have thought it my duty to withhold a considerable sum until the principal bridge is completed and properly tested, as security against a second failure. In these last mentioned particulars will be found the principal reasons for the charge made by Mr. Haupt that the prices and policy of the road have been changed. I have certainly found it necessary to add to the amount of work to be done, as shown by the returns of Messrs. Haupt & Co.'s engineers, but I think that it has been shown that no extraordinary requirements have been made which the Act will not sanction, or which are not necessary for the security of the State as well as the safety of the travelling public—and it is reasonable to suppose, that if Messrs. Haupt & Co. had been confident of completing the road under the former requirements with profit to themselves, they would not have been deterred by the temporary reduction of their estimates, but would have appealed to the Governor and Council or the Attorney-General for their decision upon the points in question, before adopting so extreme a measure as the suspension of the work. For myself I much prefer to meet whatever responsibility may attach to my present course at this time, than the condemnation of the public when the last dollar of the loan has been expended, and an incomplete and insecure road is offered for acceptance.

I have the honor to be,
Respectfully your ob't servant,
W. S. WHITWELL,
State Engineer.

[B.]

DWIGHT FOSTER, Esq., *Attorney-General:*

SIR,—That portion of the Act in relation to the Troy and Greenfield Railroad, specifying the duties of the State Engineer, does not appear to be as full as could have been desired, and I therefore would call your attention to some important points, requesting your advice to guide me in the discharge of my duties.

The Act says, "That the Engineer shall determine monthly the amount and *value* of the work done, and materials delivered on the railroad and Tunnel, &c.

He shall, monthly, estimate the proportion which the work done upon the road since the preceding estimate, bears to the whole of the work required to be done in the grading," &c. And again: "The scrip shall be delivered on the road, in the proportion which the value of the work done, and the materials delivered each month bears to the estimated cost of the whole work and materials required in the portion of road aforesaid."

Under these provisions, my first question is, Has the Engineer discretionary power to withhold payment upon such materials or such structures as he shall consider improper or defective? Has he power to say at this stage of the work what shall constitute a properly built road, and to take into account all such things as are necessary for the same, in estimating each month the amount of work to be done? Has he power to refuse payment upon any work which has not been objected to by a former Engineer, when such work is unsatisfactory to himself, and how far is his power restricted by the acts of previous Engineers?

That you may more clearly understand the bearing which these questions have upon the duties of the Engineer, I will explain the manner in which the estimates are usually made out, with some statements in reference to the estimates of June and July.

In making out the monthly estimates, the whole work done from the beginning is estimated, and the whole work remaining to be done; these two are added together, making the sum total of work upon the road when completed. Such prices are then affixed to each item of work, with some reference to its real cost, as shall make the total cost of the road absorb exactly the $650,000. These prices, so affixed, are then used again for the monthly estimate, and multiplied into the amount of the same items of work done up to the time of making such estimate, and the sum, after deducting previous payments, constitutes the amount due to the contractor. Upon the appointment of the first Engineer, an approximate estimate of each amount of work required to be done to finish the road was made, and such prices were then affixed as would absorb the $650,000. If this had been exact, (which was an impossibility,) the prices would have remained the same, and the quantities the same; but besides the usual difficulty of estimating exactly the amount of work to be done, the plan of construction has been so changed that the quantities have changed materially, and are changing from month to month, as the progress of the work exhibits with more accuracy its true cost and requirements. It is evident then that the first and most important question is to determine the amount and cost of the work remaining to be done; and in doing this is brought up the whole question of what the road should be, to fulfil the requirements of the law, and how far the judgment of the present Engineer is restricted by what has been previously allowed.

In building the road, the plan has been adopted of building over many deep ravines, with trestle-work or wooden bridging, to be replaced hereafter with earth embankments. In previous estimates no deduction has been made for the expense of making these embankments, the road having been in these places considered as finished. The slopes upon each side of the road have been left at a much steeper inclination than is usual upon the best constructed roads, and in this way the first cost has been much diminished; but as the amount saved will be required as the trestle-work decays, and the slopes slide down, it appears to me proper to add such a sum as will be necessary to do this work, to the cost of the work remaining to be done. In making the estimates of June and July, this has been done, but can be corrected if not in accordance with your view of the law. The bridging constitutes a large item of cost on this road, and as nearly all the materials have been delivered on the line of the road, if paid for at their full cost a small sum only would be left for their erection and restoration in case of accident. The plan of these bridges is not the one that I should have recommended; but having been allowed by the former Engineer, and the work being now in a very forward state, it would be manifestly unjust to the contractor to insist upon any radical change, without giving him every opportunity to make the bridge as thorough and complete as he may think necessary. The failure of one of the spans a short time since, the contractor ascribes to the use of cast-iron, where he is now substituting wrought-iron; he is also putting in an additional quantity of wrought-iron rods, and in other ways adding to its strength. But the bridge having failed once, is certainly a sufficient reason to look upon it with suspicion, so far as to induce more than usual caution in making the monthly advances. I have therefore felt it my duty to withhold a considerable sum from this work to insure the State against loss by a second failure. In these last mentioned particulars will be found the principal differences between my estimates and those previously made; and I mention it, not with any intention of asserting the superior correctness of one mode over the other, but to show how my own estimates have been made up, and that in the absence of specific instructions how different will be the results arrived at by two persons, each governed by his best judgment, and an earnest desire to do his duty.

Very respectfully your obedient servant,

W. S. WHITWELL, 13 Exchange Street.

BOSTON, July 15, 1861.

[C.]

ENGINEER'S OFFICE TROY AND GREENFIELD R. R. AND HOOSAC TUNNEL, GREENFIELD, July 25, 1861.

Hon. DWIGHT FOSTER. Dear Sir,—I feel under much obligation to you for uniformly prompt action in all matters officially brought to your notice, and for the accommodating spirit you have manifested.

It is too late now to take any action by which the mischief already done can be repaired. Under the most favorable circumstances and with the most liberal construction of the Act, the completion of the road and the accomplishment of the objects that I had marked out as essential to establish the enterprise on a sure foundation, would have absorbed all we were to receive from the State, from towns and other sources, used up our individual means and required some credit in addition; but with Mr. Whitwell's ideas the work could not have been carried on without running us perhaps a quarter of a million of dollars in debt. Under these circumstances we not only have no right to proceed, but it would have been dishonest and dishonorable in the extreme so to do. I may have a right to use up my own fortune to carry through an enterprise in which I feel an interest, but when it can no longer be carried on without borrowing money from other parties with no probability of being able to return it, then the time has arrived to stop. *I have stopped.*

When means can be provided to resume the work I am ready to take it up but I am not willing to resume it unless I can carry it through.

I expect to be in Boston on Tuesday. I enclose another circular.

Yours, respectfully,

H. HAUPT.